SCIENCE IN GENERAL EDUCATION

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SCIENCE IN GENERAL EDUCATION

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SCIENCE IN GENERAL EDUCATION

SUGGESTIONS FOR SCIENCE TEACHERS
IN SECONDARY SCHOOLS AND IN THE
LOWER DIVISION OF COLLEGES

REPORT OF THE COMMITTEE ON THE FUNCTION OF
SCIENCE IN GENERAL EDUCATION

COMMISSION ON SECONDARY SCHOOL CURRICULUM

D. APPLETON-CENTURY COMPANY
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PREFACE

Science in General Education is the report of the Committee on the Function of Science in General Education of the Commission on Secondary School Curriculum. This Commission was established by the Executive Board of the Progressive Education Association in May, 1932, and charged with the task of examining the fundamental problems of education at the secondary level.

Firm in the conviction that educational processes and goals must be relevant to the needs of the learner as he interacts with his social medium, the Commission set up, first, a Study of Adolescents to provide basic information on the problems, interests, concerns, and inclinations of young people in reaction to the situations which confront them in home, school, community, and the wider social scene.

Second, a series of Committees as established in each of a number of areas of instruction in the secondary school (junior and senior high school and junior college)—art, English, science, mathematics, social studies. This step does not represent a bias in favor of the present subject-matter organization of the secondary school; on the contrary, the basic position of the Commission implies a rethinking of subject-matter lines in terms of the needs of students. But Committees were set up on this basis both because it proved more readily feasible and because it was thought by many that recommendations in terms of subject-matter areas would be more immediately useful to teachers as schools are now organized.

Each of these Committees assumed the responsibility of exploring the contributions of its particular field to meeting the needs of young people in the democratic society of America today. In addition, each Committee undertook to implement its point of view with a series of suggestions to teachers. To these ends the personnel of each Committee was made up of specialists in the field under consideration, of secondary-school and

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college teachers, and of students of educational theory and practice. The staff of the Study of Adolescents lent its insight into adolescent development to the deliberations of each Committee, and students of society and culture were called upon from time to time for counsel. The proposals that result are designed to have bearing on the science education of all young people between the ages of twelve and twenty whether or not they are going to college.

Science in General Education thus constitutes one of a series of publications to result from the work of the Commission, its Committees in the various areas of instruction, and the Study of Adolescents.[1] Its basic approach may be briefly described as follows:

Part I makes explicit a basic point of view on the purpose of general education in a democracy and the function of science teaching in relation to it.

Part II details a corresponding analysis of the rôle of science teaching in providing experiences—in personal living, in immediate personal-social relationships, in social-civic relationships, and in economic relationships—that are conducive to personal growth and effective social participation in a democracy.

Part III treats of the individual student—understanding him and dealing with him as a unique personality, and evaluating his progress toward an ever-increasing personal adequacy and social effectiveness.

Part IV outlines some suggestions on how the teacher may make use of the report of the Committee in meeting students' needs, in understanding the student, in reorganizing courses, and in building source units.

The Appendices describe some concrete examples of science teaching, each of which is illustrative of one or more aspects of the various proposals and suggestions of the previous text.

From this outline it will be gathered that the Committee conceives of science teaching within the context of the whole process of general education, that its proposals are relevant both to what

[1] *Teaching Creative Writing,* by Lawrence H. Conrad and the Committee on the Function of English in General Education, published in the spring of 1937 by D. Appleton–Century Company, Inc., was the first of these publications.

the student now is and to what he may become as a responsible member of society, and that it assumes a democratic way of life as a guide to its goals in education. It is hoped that teachers who read the volume will not look upon its specific suggestions merely as materials to be added to the now existing curriculum. Continued accretions have already rendered the offerings in secondary education confused and burdensome. Application of the proposals of this report should instead lead to the revaluation and elimination of many materials now in use, and to the organization of a program consonant with the conception of science teaching proposed.

Since the Committee on the Function of Science in General Education has worked as a seminar group, meeting frequently to take account of the results of the Study of Adolescents and to discuss tentative statements of one section or another of this report, it has been necessary to restrict active membership quite largely to people in close geographical proximity to the headquarters of the Commission in New York City. The frequency of meetings and the amount of time required by membership on the Committee have made it necessary to rely upon people who could give practically all of their spare time to this particular work.

On the other hand, prior to issuing this final report, the Committee submitted its tentative findings for criticisms and suggestions to numerous groups of science teachers drawn from different geographical regions and working under widely varying conditions. It is particularly indebted for criticism, suggestions, and contributions received from members of the science group in the Summer Workshops of the Progressive Education Association held at Columbus, Ohio, in 1936 and at Bronxville, New York, in 1937.

In the course of its work the Committee's membership has shifted considerably. This fact renders it difficult if not impossible adequately to acknowledge indebtedness to all individuals who have contributed to the report. Consultants to whom special acknowledgment is due are Karl W. Bigelow, American Council on Education, and Teachers College, Columbia University; Ralph W. Tyler, Ohio State University, and the Evaluation Staff of the Commission on the Relation of School and College, Pro-

gressive Education Association; Henry A. Kelly, Fieldston School, New York City; Homer W. LeSourd, Milton Academy, Milton, Massachusetts; and Ellsworth Obourn, John Burroughs School, St. Louis, Missouri.

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Addressed primarily to teachers of science, this report bears import for a far wider group, first, because of the way in which it approaches its problem specifically and explicitly through an examination into the goals of general education in the secondary school—a discussion worthy of consideration by all educational workers at this level; and second, because the function of science teaching cannot be performed by teachers of science alone, as the text of the report makes evident, but calls upon the understanding and insightful coöperation of teachers in many if not all of the other areas of the school.

To this larger group, then, as well as to teachers of science,

this volume is offered in the hope that it may prove of service in clarifying the appropriate goals of education for adolescents in America today.

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Part I

SCIENCE TEACHING IN RELATION TO GENERAL EDUCATION

I

INTRODUCTION

WHY THE SCIENCE PROGRAM OF THE SECONDARY SCHOOL REQUIRES CONSIDERATION

Careful examination into the purposes and procedures of science teaching and its function in the education of the adolescent is appropriate for two reasons. The first of these is the increasingly significant effect which the sciences, their applications, and the scientific point of view are having upon social organization, cultural patterns, and consequently upon the life of the individual. The second lies in a prevailing confusion as to goals, functions, and procedures in the field of science teaching itself. Nor are these two sources of demand for reëxamination and reformulation unrelated; clarification of purposes and programs must of necessity take place in terms of a conception of education consonant with the times, so deeply affected by developments in the sciences.

Instruction in the sciences has had an important place in the program of secondary education for many years. The rôle that it should be called upon to play today is undoubtedly more prominent and significant than ever before. Technological advances in means of production, transportation, and communication are having profound effects upon the material aspects of the culture. The problem of how best to use the results of these advances is ever before us. Man's ways of thinking and his outlook upon life—particularly in relation to his conception of the universe and his place in it—continue to be deeply affected by advances in science. Further, the sciences

have provided a great many tested methods and techniques which man can use with confidence and efficiency in attacking his problems. Yet the use of these tools in solving the crucial problems of social living is, in large measure, only a promise for the future. These facts all point to a new and increasing responsibility for the science program of the school.

In addition, it is generally recognized that there is much confusion in the field of science teaching, both about the purposes which this instruction should serve and the most effective procedures for realizing these purposes. Society has changed so rapidly that educators have found it difficult to devise educational programs adequate to meet the new conditions of living and their accompanying changes in human thinking and action, and the confusion in the field of science teaching is undoubtedly only an aspect of the uncertainty that now characterizes the field of education in general. Like teachers in other fields, teachers of the sciences are scrutinizing their practices in the light of new demands and are becoming genuinely concerned as to whether time-honored objectives, materials, procedures, tests, and examinations are as adequate and as effective as it is possible to make them.

Does the training now given in scientific method, for example, actually carry over into life situations? Is there adequate evidence that science instruction has succeeded in developing citizens who actually utilize the methods or the spirit of the sciences in dealing reflectively with the significant problems of living? Are current methods of testing in general use by science teachers even designed to show whether the student can use scientific method effectively in his work in the sciences, to say nothing of his ability to use it in other fields?

Though no categorical answers to these challenges can be given, it is certainly desirable to take stock of the purposes of science teaching and to estimate the degree to which they have been achieved through the programs and procedures upon which reliance has been placed.

THE HISTORY OF SCIENCE TEACHING IN THE SECONDARY SCHOOL: CONFUSION AS TO PURPOSES AND PROCEDURES

A brief examination of the history of science teaching in relation to present goals and practices reveals some of the origins and causes of the confusion prevailing in the field and may serve as a basis for a constructive approach to the contemporary problem. This history indicates that many differing purposes for instruction in the sciences have been proposed at different periods; that these purposes have been embodied in many differing programs and practices; and that the purposes and practices of any given period have tended to persist, in part at least, into succeeding periods. This means that present-day programs have been built up by adding new ideas and practices to those carried over from before. The appropriateness of previous goals and procedures to new conceptions and demands has not always been carefully considered, and in some cases incompatible aims and practices are now being carried along side by side.

For purposes of discussion, the history of science teaching in American secondary schools may be divided roughly into three periods. The first begins with the establishment of the academy in 1751 and extends until approximately 1880; the second extends from this date to 1910; and the third reaches into the present. Although natural philosophy and astronomy were taught in some schools which antedated the academy movement, instruction in the sciences in this country had its real beginning in the Philadelphia Academy founded by Benjamin Franklin in 1751.

In his proposal for an academy,[1] Franklin held that "histories of nature" should be read by young people who intended to become merchants in order that they might better understand the commodities which they sold, by those who

[1] Benjamin Franklin, *Writings,* Smyth ed. (New York, The Macmillan Co., 1907), Vol. II, p. 395.

intended to become craftsmen in order that they might learn how to use new materials, and by those who intended to enter the ministry in order that they might better understand proofs of the existence of God and present them more satisfactorily. In addition to these very practical reasons for the study of science, its help in conversation was also argued by Franklin because so many occasions afforded opportunity for making observations on natural phenomena. Incidentally, his proposal that the study of science be accompanied by actual practice in gardening and by frequent excursions to near-by farms for the purpose of studying the best methods of planting and cultivating affords an early example of the advocacy of the laboratory method.

The aims of science instruction during this period were quite generally threefold: descriptive, utilitarian, and religious. The sciences taught during the period consisted, in the main, of natural philosophy, astronomy, chemistry, and geography, with some emphasis upon zoölogy and geology. Instruction was organized to facilitate the presentation of factual material with little regard for developing relationships. Indeed, some of the early texts were written in the form of catechisms. The predominant method of teaching was the assigning of material to be learned and the hearing of recitations on the assigned material. All of this would appear to indicate a value placed upon the ability to describe natural phenomena as an end in itself.

The utilitarian note struck by Franklin continued as the dominant emphasis in most of the science teaching throughout the period. But it is interesting to note that much of this early science instruction was simultaneously marked by a strong religious note. Particularly was this true in the case of natural history, zoölogy, astronomy, and geology. The textbooks widely used at the time indicate that their authors utilized facts of these four sciences in order to prove that the Creator was wise and benevolent, and in order to

strengthen the student's faith in a supernatural ordering of natural events.

Although there can be no doubt that this type of instruction aided in giving students an acquaintance with natural phenomena, particularly as they were related to the practical aspects of life, yet its aims and methods were scarcely such as to develop original and independent thinking. Dewey's famous statement to the effect that "information severed from thoughtful action is dead—a mind-crushing load," might well be exemplified by much of this early science teaching.

Yet these three aims—the utilitarian, the religious, and the descriptive—were not abandoned at the close of the period. Even modern science courses place a very strong emphasis upon practical applications, and the organization of such courses as household chemistry, industrial physics, and the like is evidence of the extension of the early utilitarian aim.

Since modern science tends to reject teleological explanations, the use of the sciences in "revealing the wonders of divine creation" is no longer as common as it was in the nineteenth century, but examples of it are still to be found, not only in classroom practice, but in modern textbooks as well. In some parts of the country where "fundamentalist" religious views are dominant, the teaching of science is designed to help students see a religious purpose in the world, and in books, magazine articles, and public addresses a few contemporary eminent scientists interpret modern physics to support certain religious views.

And even the descriptive aim persists. Though few modern science teachers would hold that a knowledge of facts for their own sake is desirable, it is well known that a large part of their time is still occupied by teaching isolated facts and testing students' retention of them.

During the next period (1880–1910) there was a marked shift in the aims of science instruction. Generally speaking,

the utilitarian and religious aims gave way to that of training the mind, whereas the emphasis upon drill on factual information continued—partly in the guise of memory training. For this was the heyday of faculty psychology and the doctrine of formal discipline. On the basis of these as a premise, it was held that the study of the sciences possessed particular merits, not to be achieved in the pursuit of other studies: they provided unique opportunity for mental discipline by training the faculty of observation, promoting the concentration of thought and energy, and providing sense training through the manipulation of materials.[2]

Since under this theory all individuals were presumed to have minds made up of the same faculties which needed to be trained, science teaching was carried on with little or no regard for the particular interests and needs of the learner. Emphasis began to be placed universally upon preparation for college—a trend accentuated by the work of the Committee of Ten whose report dominated the high schools for many years. This Committee was unanimously of the opinion that no differentiation in courses should be made between students who intended to go to college and those who expected to enter vocational life directly from the secondary school, for it followed on the postulate of mental discipline that trained faculties were the contribution of secondary education to preparation for both life and education.

This period also marked the introduction and popularization of the laboratory method, hailed as a means of making science teaching vital and effective. Here again there was the same emphasis upon a psychology which has now been abandoned: laboratory exercises were planned to provide for the training of the faculties. It was held that such work gave

[2] For evidence on this point see: Frank Wigglesworth Clarke, "A Report on the Teaching of Chemistry and Physics in the United States," United States Bureau of Education, Circular of Information No. 6, 1880, p. 10. James H. Shepard, *Elements of Inorganic Chemistry, Descriptive and Qualitative* (Boston, D. C. Heath and Co., 1887), "Notes to Teachers," p. vii. *Report of the Committee of Ten on Secondary School Studies,* Published for the National Education Association by the American Book Co., 1894.

opportunity for the cultivation of accuracy in observing changes in phenomena, for developing systematic habits of work, and for training in the power of reasoning from a particular set of observations to a general law. The keeping of a laboratory manual was held to give valuable training in habits of neatness and precision of expression. Some writers seem to have thought that the case for laboratory work was advanced by the claim that it was as valuable for "discipline" as were Latin and Greek.

Under the impetus of the disciplinary aim subject-matter was systematized and formalized. It was the time of meticulous classification of plants and animals, of attention to details in laboratory "experiments," and of complete systematization of knowledge. The fact that knowledge in this form was more difficult for the learner to acquire was held to be a point in its favor—it possessed greater disciplinary value.

Though modern psychology has given experimental proof that the conception of mental discipline is inadequate, much of current science teaching is not only congenial to this outmoded theory, but can be justified only in terms of it. The all too prevalent practice of requiring the memorization of fixed quotas of factual materials, the assigning of problems selected primarily for their difficulty, the attention to abstract reasoning—all out of relationship to life situations—are evidence of the persistence of the faculty theory of mind and its correlative educational aim, mental discipline.

The third period [3] represented a reaction against the disciplinary aim and against college preparation as the chief function of science teaching. In a sense this reaction tended to revert toward the descriptive-informational and utilitarian aims stressed in the earlier schools, but it represents an

[3] For general information on this period see the following: "Vitalizing the High School Curriculum," *Research Bulletin* of the National Education Association, Vol. 7, September, 1929. John Elbert Stout, *The Development of High School Curricula in the North Central States from 1860 to 1918* (Chicago, The University of Chicago, 1921). Paul Johnson Fay, *The History of Science Teaching in American High Schools,* Unpublished Ph.D. dissertation, Ohio State University, 1930.

attempt to meet the demands of modern industrial society by emphasizing newer developments in science and seeking to make the sciences play a more active rôle in the lives of students.

The fact that this period was marked by a rapid increase in the secondary-school population is not irrelevant to this shift in emphasis. The secondary school was rapidly changing from an institution that trained intellectually élite young people for leadership to one that sought to meet the needs of "all the children of all the people." From 1900 to 1930, the proportion of youth fifteen to seventeen years old enrolled in school increased from 40 to 67 per cent; and from 1890 to 1934, the senior high-school enrolment (grades ten to twelve) increased from 6 per cent of the number in the same age group to 54 per cent. These increases were, of course, accompanied by a lowering of the socio-economic status of the general level of secondary-school students, a lowering of the average of academic intelligence, and a shift from predominance of students destined for upper middle-class professions to those going into lower middle-class vocations and occupations requiring little or no specific academic training. In view of these marked changes in the character of the secondary-school population, it is no wonder that college preparation was abandoned in favor of preparation for everyday life as the aim of secondary-school instruction.

The fact that physics, physical geography, and physiology declined somewhat in popularity during this period is probably explained in part by the failure of science teachers to adapt their materials and methods to new conditions; an accompanying rise in enrolment in courses in general science and biology is to some extent accounted for by the fact that these courses were better organized to meet student needs than were some of the older science courses.[4]

[4] From 1900 to 1928 the percentage of secondary-school pupils enrolled in physics dropped from 19 per cent to 6.9 per cent; chemistry remained about stationary; physical geography dropped from 23.4 per cent to 2.7 per cent; physiology dropped from 27.4 per cent to 2.7 per cent. These decreases were

One of the first attempts to develop a more functional approach in science instruction was made by the Commission on the Reorganization of Secondary Education, appointed by the National Education Association, in its well-known report, "Cardinal Principles of Secondary Education" (1918).[5] This report was an attempt to lead education away from the narrow, factual, disciplinary emphasis to a broader conception which stressed the functional requirements of the learner. It held that education should contribute to (1) health, (2) command of fundamental processes, (3) worthy home membership, (4) vocation, (5) citizenship, (6) worthy use of leisure, and (7) ethical character. These seven "principles" were not so much objectives as categories for the classification of human activities, and all subjects of the curriculum were to be taught in such way as to lead to achievement in each. What actually happened in many cases was that the various subjects of the curriculum were parceled out among the "principles"; literature and the arts, for example, were taught so as to contribute to the achievement of worthy use of leisure time; the social studies to citizenship; home economics to worthy home membership; and science to health and vocation.

In 1920 the Commission issued its bulletin on "Reorganization of Science in Secondary Schools" [6] in which, after making severe criticisms of the then prevalent practices in science teaching, it urged that the sciences be organized and taught in such manner as to contribute to all the "cardinal principles" except the second—the command of fundamental processes. A number of methods were suggested as means of securing these outcomes. The most significant of these was the "project" method; working under this plan, the student would be allowed to carry on a wide range of activities, in-

accompanied by increases in biology and general science. These figures should not be taken too literally because the proportion of students remaining in high school until graduation changed during the period.

[5] *Bulletin* of the United States Bureau of Education, No. 35, 1918.

[6] "Reorganization of Science in Secondary Schools," *Bulletin* of the United States Bureau of Education, No. 26, 1920.

cluding the study of books in the library, the construction of exhibits, and the devising of original experiments.

The next definite attempt to make instruction in each subject effective in all areas of living was made by the North Central Association of Colleges and Secondary Schools in 1926. In that year the report of its Committee on Standards for Use in the Reorganization of Secondary School Curricula held [7] that all subjects should contribute to the achievement in terms of four "ultimate objectives": health, vocation, social relationships, and leisure time. It then proceeded to develop units of subject-matter designed to contribute to the attainment of these four objectives. Although it is still too soon to appraise the work of this Committee in the field of science instruction, its program has undoubtedly brought to the attention of the science teacher the possibility of utilizing a much wider range of material and the importance of teaching science so as to meet the everyday needs of youth.

Another report which has had considerable influence upon science instruction was published by the National Society for the Study of Education in 1932: *A Program for Teaching Science*.[8] This report placed considerable emphasis on the contribution of science learnings to a liberal education, set up "life enrichment through participation in a democratic social order" as the aim of education, and proposed a complete program for science instruction throughout the school system. Its greatest contribution was perhaps the plan for organizing subject-matter and learning experiences around "interpretative generalizations" or "big ideas" which are significant for a liberal education, rather than around the laws and theories of pure science. These laws and theories are important mainly as a means of organizing the knowledge of

[7] "Report of the Committee on Standards for Use in the Reorganization of Secondary School Curricula," *North Central Association Quarterly,* Vol. I, March, 1927, pp. 428–444.

[8] *Thirty-First Yearbook* of the National Society for the Study of Education, Part I (Bloomington, Ill., Public School Publishing Co., 1932). The debt which the present report owes to this work will be apparent, particularly in the chapters dealing with content and methods of science instruction.

the scientist, whereas interpretative generalizations based on the contributions of the sciences—particularly the physical sciences—have proved fruitful in the thinking of laymen for several hundred years. This proposal to employ them consciously in a program of education represents a significant forward step.

The present status of science teaching is difficult to determine. One of the most recent pertinent studies, "Instruction in Science," was made in 1932 by Wilbur L. Beauchamp,[9] who analyzed fifty-eight courses of study in general science, forty-five in biology, twenty-seven in physics, and thirty in chemistry, all of which had been revised since 1925. He also visited schools in fourteen cities in various parts of the United States for the purpose of determining the extent to which courses of study were actually effective in determining subject-matter and methods, and "to discover promising innovations in classroom technique."

This study revealed that science teaching at present is a mixture of the orthodox practices of the period 1880–1910 and the emerging practices of the last two decades. It thus combines much of the aim of mental discipline (presumably to be achieved through the study of a systematic organization of facts) with the aim of showing the importance of pure and applied science in modern life. In addition, it seeks to meet the needs of the individual in everyday life by imparting useful scientific information.

The newer courses, general science and biology, now firmly established in the curriculum of the secondary school, employ the predominant educational aims of the period in which these courses came into existence (1910–1925). The older courses, physics and chemistry, show greater emphasis upon mental discipline, although many high-school and college courses in these subjects exhibit the emphases of more recent years.

[9] "Instruction in Science," *Bulletin* of the United States Bureau of Education, 1932, No. 17, National Survey of Secondary Education, *Monograph* No. 22.

An examination of even the stated objectives of science teaching revealed little or no general agreement about what this instruction is supposed to accomplish. "To acquire knowledge which will produce a better understanding of our environment," "to acquire a knowledge of the fundamental principles of the subject," and "to develop the ability to think scientifically" were mentioned with some frequency, but there is no reason to suppose that as many as half of the teachers responsible for the construction of the courses studied believe that science should be concerned with "ability to think." Only two courses in biology out of a total of thirty-two examined deal with the development of an "appreciation of the contributions of the scientific method," and only one considers the "contribution of science to mankind." In the other special fields the figures are quite similar.

When the actual content and conduct of courses were studied, the emphasis upon "covering ground" without reference to the function of the content in orienting the pupil was clearly evident. For example, forty out of forty-five courses in biology are short treatments of botany, zoölogy, and human physiology, considered separately, and exhibit little attempt to use these life sciences to bring out the relationships of the activities and processes of living things to the life of the pupil. Beauchamp puts the situation very clearly in the following statement: [10]

> Courses organized on the above basis [fragments of botany, zoölogy, and physiology] appear from their content to focus the attention of the pupils on a body of isolated facts concerning different living things. A study of a grasshopper or a crayfish consists primarily in securing a description of the structure, habits, and economic importance of these animals. Observation in the classroom justifies this implication from the courses of study. Two observations which are typical of the many classes visited are offered in support of the same inference. In one class the topic under discussion was the earthworm. The following questions

[10] *Ibid.*, p. 33.

[out of a total of twenty-six similar ones] were asked by the teacher [in a forty-five minute period]: (1) In what ways does the dorsal surface differ from the ventral surface? (2) How many somites are there from the anterior end to the girdle? (3) What is the extent of the body cavity, posteriorly and anteriorly? (4) How does the earthworm move? (5) How does the earthworm reproduce? (6) Tell what you know about the digestive apparatus of the earthworm.

Certain distinct deviations from dominant practice observed by Beauchamp very likely indicate significant trends in science teaching. Among these the following may be mentioned: organization of courses around major concepts, emphasis upon interpretation of the environment, concern with methods of teaching, the problem method of developing a topic, increased use of the demonstration method, use of "study guides," use of illustrative material, supervised study, less emphasis upon formal records, more emphasis upon visual aids.[11] There is much evidence to support the conclusion that a number of these trends have become increasingly significant during the past five years.

This brief survey of present trends in science teaching reveals that there is probably less agreement as to the purposes of science instruction at the present time than there was in previous periods. This increasing confusion is due in part to the fact, earlier noted, that purposes and programs that were reasonably successful in a given period have been carried along and still permeate practice, even though the conditions that gave them validity have now changed.

A shift in psychological theory during recent years has also contributed largely to the disorder and perplexity. As long as education could be conceived as consisting mainly in the training of the faculties, the purpose of science instruction was clear. Scientific information was organized in systematic and logical fashion, and laboratory work was carried on with meticulous detail in order to train the faculties of observation, memory,

[11] *Ibid.*, pp. 62–63.

reasoning, and the like. However, as the science of psychology advanced, new theories of the nature of the learning process supplanted the basic assumptions of faculty psychology. Doubts were cast not only upon the existence of faculties but also upon widespread transfer of training.

Among others, "the stimulus-response" school of psychologists came into prominence at this time. This school emphasized analysis of a situation into fixed elements to which specific responses were to be established as the most important aspect of learning, and this afforded science teachers a way out of their difficulty. Since no great degree of transfer of training was to be expected, it was necessary to establish fixed responses to unit situations and to teach rather specific important facts. What facts were important could be discovered, according to this theory, through job and activity analyses.

The organization of courses in applied science and the increasing emphasis upon concrete applications of science to everyday life were an outgrowth of this new development in psychology. They were stimulated also by several related considerations: by the rejection of the theory that the same science should be taught to every pupil regardless of interests or needs, by serious doubts regarding the ability of the student to transfer principles to differing situations, and by the practical demands of the increasingly large number of students who entered the secondary school.

At the same time that the stimulus-response school of psychologists was influencing educational practice, another group of psychologists and educational philosophers led by Dewey, Kilpatrick, and Bode was calling into question some of the more extreme assumptions deriving from this theory of the nature of learning. This latter group emphasized the rôle of synthesis in learning—rather than analysis of situations into unit stimuli for the learning of unit responses—and gave prominent place to the learner's purpose and intrinsic motivation. More recently the mental hygienists have

stressed a study of the individual's basic emotional drives as a means of determining his needs.

The impact of these newer movements upon science teaching has made even more crucial the current necessity for a reëxamination of its basic purposes and the programs effective in their achievement.

THE PSYCHOLOGICAL BASIS FOR A NEW APPROACH

As noted earlier in this chapter, the perplexities of science teachers reflect perplexities in the field of education in general. In addition, only desultory attempts have been made to relate science instruction, particularly in the special fields, to general education.

For these reasons the Committee has found it advisable to seek a basic frame of reference that will serve to define the rôle of science instruction in general education and help to eliminate the confusion that has resulted from the use of differing and sometimes incompatible theories of learning. The remainder of this chapter is devoted to discussion of the psychological point of view on which the Committee's theory of education is based. The other aspects of its frame of reference will be discussed in Chapter II.

Any theory of learning must take its departure from a conception of the nature of the individual, the human organism. Fundamental to the Committee's thinking is the fact that the human organism is inherently characterized by tensions between itself and its environment, and that its activities represent the attempt to satisfy these tensions. This is a continuous process. Unless the individual is asleep, he is always, in greater or less degree, active in the satisfaction of some urge, for he is so constituted that absence of tension, if prolonged, itself constitutes an urge—the urge to relieve boredom. He is not necessarily, however, conscious of the urge he is striving to satisfy; when he is, when he directs his efforts knowingly to an end, he has a purpose. But all be-

havior goes on in these terms, the individual striving through interaction with his environment to satisfy tensions which he feels.

It is this fact which gives point and character to behavior. What the individual does in any situation depends primarily on the urge he is attempting to satisfy, the tension he is trying to resolve. The terms in which the tension exists *for him* significantly determine his behavior. Bode exemplifies this active and selective character of the individual's urges and tensions as follows: [12]

If a person is very hungry, for example, his senses are on the alert and he is quick to respond to anything that may have to do with eating. Instead of waiting passively for stimulations to come, the organism seeks them out. All sorts of sights and smells that would ordinarily pass unnoticed are responded to and made much of. Thus a faint smell is laid hold of and transformed into visions of cookery; a slight noise is transformed into a dinner call, and so on. Similarly the craving for excitement in small boys translates all sorts of ordinary objects into opportunities for creating a disturbance, with a facility or ingenuity that to older people often borders on the diabolical. The particular "set" creates a high degree of sensitiveness or readiness to react; in psychological terms, the threshold of sensitivity is low. If a person has just had a good dinner, or if he is tired, this sensitivity undergoes a change; the opportunities to eat or to create excitement

[12] Boyd Henry Bode, *Conflicting Psychologies of Learning* (Boston, D. C. Heath and Co., 1929), p. 237.

For further discussion of this dynamic view of learning see: V. T. Thayer, *The Passing of the Recitation* (Boston, D. C. Heath and Co., 1928), Chs. VIII and IX. John Dewey, *Human Nature and Conduct* (New York, Henry Holt and Co., 1922), Part I. William Heard Kilpatrick, *A Reconstructed Theory of the Educative Process* (New York, Teachers College, 1935). H. S. Jennings, *Behavior of the Lower Organisms* (New York, Columbia University Press, 1906), Chs. XVI and XVIII, and *The Biological Basis of Human Nature* (New York, W. W. Norton and Co., 1930). Raymond Holder Wheeler and Francis Theodore Perkins, *Principles of Mental Development* (New York, Thomas Y. Crowell Co., 1932). G. E. Coghill, *Anatomy and the Problem of Behavior* (New York, The Macmillan Co., 1929). K. S. Lashley, *Brain Mechanisms and Intelligence* (Chicago, University of Chicago Press, 1929). Orville G. Brim, *The Foundations of Progressive Education* (Columbus, Elementary Education Club of Ohio State University, 1935).

tend to pass unnoticed. The threshold of sensitivity is then high. In other words, the organism is no longer in search of stimuli that can be made over into objects which will further the organic activities.

But even though the situation is interpreted in terms of the unique tensions of the individual, the demands of the environment, its realities and expectations, also influence his efforts. For the human organism must be thought of as operating always in relationship to its environment. As Dewey explains: [13]

> Breathing is an affair of the air as truly as of the lungs; digesting an affair of food as truly as of tissues of stomach. Seeing involves light just as certainly as it does the eye and optic nerve. Walking implicates the ground as well as the legs; speech demands physical air and human companionship and audience as well as vocal organs.

To think of the individual apart from his environment is in fact to deal with an abstraction.

The impulses of the individual take on character only when they involve interaction with the environment. His interests and impulses both modify and are modified by persons and events about him. Personality emerges from the interaction of constitutional and environmental factors.

This conception of the nature of individual behavior places an emphasis upon "continuous reconstruction of experience" of the learner as the essence of education. It implies a rather complete rejection of the stimulus-response concept of learning (the analysis of situations into fixed elements to which unit responses are learned one by one); on the contrary, emphasis is placed upon the total situation. Learning takes place through the reorganization of the individual's present behavior patterns (or "wholes") into more inclusive, more adequate patterns by bringing together any

[13] John Dewey, *Human Nature and Conduct* (New York, Henry Holt and Co., 1922), p. 14.

"elements" that have meaningful relation both to the individual's behavior pattern and to the situation at hand.

This reorganization process is, as has been pointed out above, a selective one, the selection being made in terms of the need which the individual is attempting to satisfy. To him the total situation is not merely the sum of its parts; in its entirety it constitutes a meaningful pattern from the context of which the various elements to which he gives attention take on their meaning. Thus, to use Koffka's [14] illustration in explaining the behavior of the apes in Koehler's experiments, a stick which in one situation was merely "something to bite upon," becomes transformed into a "thing to fetch fruit with" when seen in connection with a new situation that involved the securing of a banana placed outside of the cage and out of reach of the ape. This point of view on the wholeness of the situation in the experience of the learner is further illustrated by Ogden,[15] who points out that sounds are modified by other sounds that occur at the same time. He says:

> . . . Membership in a clang alters the phenomenal character of the partial tones. . . . A phenomenal *configuration,* such as a clang, is both something more than and something different from the sum of its ingredients; for these ingredients are no longer separable entities, but members of a "whole" and being such they must lose some, indeed a great deal, of their individuality.

Not only does the individual respond to a situation as a whole; within himself, he operates as a whole. As he deals with the situation, he learns physically (acquires a certain deftness, changes certain glandular responses, etc.); he responds emotionally; he builds attitudes; he finds out what will work and what won't work in analogous situations; and he organizes, on his level, the meanings which the situation

[14] Kurt Koffka, *The Growth of the Mind,* textbook ed. (New York, Harcourt, Brace and Co., 1924), p. 191.

[15] Robert Morris Ogden, *Psychology and Education* (New York, Harcourt, Brace and Co., 1926 ed.), p. 150.

has for him—all of these responses being in progress at the same time.

This means that it is impossible to separate the individual, except for purposes of study, into physical, intellectual, or emotional parts. Any response which he makes is always a resultant of physical, intellectual, emotional, and environmental factors; each phase of personality is influenced by and dependent upon the others, all acting simultaneously. This interaction is so marked, and the interconnections among the parts so extensive and intimate, that a change in any one field may manifest itself, not at the point of origin, but in other parts of the organism which constitute the whole. And what he learns at a given time enters into the peculiar combination of longings, desires, attitudes, skills, understandings, that will motivate his response to the next situation.

From the point of view of mental hygiene the significant factor in the process described is the emotional satisfaction or lack of it resulting from the experience. The deposit from any experience enters, as has been discussed, into the next experience. The experiences of early childhood seem to be peculiarly strategic. But at any period in life the manner in which physical, intellectual, and emotional needs have been met in the past will affect reaction to present experience, including school experiences. Educationally this means that the learning process is integrally bound up with the individual's emotional life, as well as with his physical and intellectual life, and that the whole individual must be understood and dealt with adequately if learning is to be effective and satisfying.

According to this psychology, then, it seems evident that in order to deal helpfully with a person it is necessary to be sensitive to the factors that are motivating his efforts. The most capable and genuinely well-meaning teacher can be effective only in this framework, for the student evaluates what is proffered by teachers or other adults in terms of his needs and values—he will reject it, accept it, or incorporate it into

his patterns of behavior only according as *he* feels its significance (except possibly to relieve pressures of the moment).

In the field of science instruction this view points also to an emphasis upon learning in terms of large understandings, with analysis and synthesis going on simultaneously, and upon reflective thinking in which induction and deduction are both utilized. Factual information, drill, and memorization are to be subordinated to more significant goals.

The position of the Committee with respect to the psychological basis of science instruction may then be summed up as follows: The individual is seen always in interaction with his environment, and it is necessary to take account of this fact in order to understand and deal helpfully with him. The multitude of needs characteristic of any individual grow out of this dynamic quality of human life; the individual is active and purposeful in the attempt to satisfy drives which take on meaning and character in interaction with his environment. It is his peculiar combination of needs, longings, desires, and his preferred ways of meeting them which constitute his uniqueness and which define the effective approach to him. Whatever goes on as he deals with his environment leaves its effect on him physically, emotionally, intellectually—he learns as a whole.

Learning at its best is characterized by the application of intelligence to the meeting of needs. No fixed formulas can be prescribed for the appropriate satisfaction of needs, for they are continually developing and expanding and are frequently in conflict with one another. Since the total situation in which the individual lives and grows is constantly in a process of change, novel adjustments are called for—hence the Committee's insistence upon the view that thinking is the method of securing adequate control over experience. It is the business of the teacher then to understand the nature and needs of the individual in his manifold relationships of living and to help him to meet his needs in such a way as to make life ever richer and more meaningful.

II

THE PURPOSE OF EDUCATION IN A DEMOCRACY: IMPLICATIONS FOR THE SCIENCE PROGRAM

In Chapter I the Committee described the present status of science teaching in the American secondary school. It pointed out the need for a clear sense of direction in order to meet the persistent demands being made upon all areas of the secondary-school program. These demands result from the impact of science upon human living, from changes in psychological theory, from new conceptions of the responsibility of the school in a democratic society, and from a tremendous increase in the secondary-school population and a corresponding change in its character. All these have served to emphasize the need for critical examination of current practices.

The present chapter makes more explicit the viewpoint of the Committee as to the purpose of general education and presents in more detail the frame of reference used in later sections on the science program.

THE PURPOSE OF GENERAL EDUCATION

Great difficulties are involved in attempting to state concisely the all-inclusive purpose of secondary education. A formulation of this sort is bound to be abstract and subject to many interpretations, depending upon the reader's background of experience. Yet, since such a statement sets the stage for this chapter, we propose to make the attempt and then to proceed at once to clarify its meaning.

THE PURPOSE OF GENERAL EDUCATION IS TO MEET THE NEEDS OF INDIVIDUALS IN THE BASIC ASPECTS OF LIVING IN SUCH WAY AS TO PROMOTE THE FULLEST POSSIBLE REALIZATION OF PERSONAL POTENTIALITIES AND THE MOST EFFECTIVE PARTICIPATION IN A DEMOCRATIC SOCIETY.

Such a statement calls for amplification at many points, and to this task the present chapter devotes itself. The discussion proceeds along three main lines corresponding to the emphases above: the first of these centers around the conception of needs of individuals as a primary concern of general education; the second has to do with the major ideals of the society in which the individuals are to function—a democracy; the third is concerned with the personal qualities essential to effective functioning in such a society.

NEEDS IN THE BASIC ASPECTS OF LIVING

Needs as an Approach to Curriculum Construction

The Committee is not, of course, proposing a curriculum based on the notion that the adolescent is always conscious of his needs or of his range of interests, or that he be permitted to do as he pleases. Neither is it proposing a curriculum based solely upon an adult conception of what is valuable as a preparation for adult living.

The preceding discussion has pointed out how strategic are the tensions, urges, desires, needs of an individual in his behavior and its reconstruction. These needs not only determine the way in which he sees situations, uses and modifies them, but they also furnish clues to the ways in which it is possible to deal effectively and educationally with him. He interacts with his environment in terms of these motivating factors; both it and he are remade accordingly. His needs are reconstructed in the course of this experience; he behaves differently in consequence and has a different effect upon his environment.

For these reasons, many curriculum-making groups—having rejected the externally imposed curriculum characteristic of secondary schools in the past—are seeking a new orientation in terms of student needs. The Committee likewise proposes that needs serve as a point of departure in curriculum construction.

The difficulty with the new approach, however, is that the word *need* has a variety of meanings. What is meant when it is claimed that the curriculum of the secondary school should be based upon the needs of adolescents? To some it means that all learning activities should spring from the immediate *felt* need or desire of the student. This position obviously carries with it certain very definite limitations. To others the conception means that society makes certain demands upon the individual, that the teacher's business is to discover what these demands are and to organize learning experiences to meet them. Hence, the teacher can truthfully say that John *needs* physics—or, more specifically, he *needs* to know Boyle's law. Between these two extremes there are, of course, many widely differing interpretations. In the face of this chaotic situation, it is necessary for those who use the term to make clear, by either definition or context, the meaning they have in mind.

In the opinion of the Committee, the most helpful, as well as the most accurate, way of looking at this conception is to regard needs as personal-social in character. As discussed in the previous section, a need will have always a personal or individual aspect which may best be understood as a biological or somatic tension. Expressed in common terms it refers to some want or desire which the individual seeks to satisfy. But wants or desires are not to be determined by studying the individual out of relationship to the social environment or the culture patterns in which he is enmeshed. Needs do not exist "under the skin" of the individual or in a vacuum. They arise and work themselves out in living, dynamic events which can only be described as *interactions between the individual and the social situation*. Thus when we speak of "the need of the student to select and use goods and services wisely," we refer to a want (biological tension) or a desire on the one hand, and the requirements, demands, standards of social living on the other. To speak of a need without including both its *personal* and *social* aspects is to leave out an indispensable element. Merely

to say that John wants something, or that Teacher X believes John needs a particular piece of knowledge, is to leave out the element of *interaction* between the two necessary components.

Now when the term *need* is used in this manner, it is evident that in any need as it exists at a given moment the two aspects will be present in varying degrees. Indeed the emphasis shifts back and forth from one aspect to the other. Some needs, such as the need for "self-assurance," are more personal in character, whereas others such as "the need to participate with others in social-civic life" show more obviously their involvement in the social scene. But in the case of both of these illustrations, the two aspects are present. Self-assurance cannot be attained except with reference to situations involving the environment, typically, also, involving other persons; if it were possible for a person to exist in a vacuum, the problem of self-assurance would never exist for him; on the other hand, there would not be participation in social life except because of the needs of individuals. In the first illustration the teacher may be chiefly concerned with establishing fruitful relationships between the individual and environment and directing the "need for self-assurance" into socially desirable channels. In the second illustration, the teacher may be concerned primarily with discovering the personal, individual tension which calls for participation with others and with ways of directing it profitably. At the risk of seeming to labor the point, it must be said that the teacher must be concerned with the total situation in which the interactions are taking place.

From the foregoing discussion it should be clear that a need —the tension in the already organized personality of the adolescent as he interacts with the demands of the environment and the standards or ideals which it sets—is truly unique with the individual. From this it follows that a given experience, outwardly the same for two students, may be inwardly different for them and require quite different educational direction. It should be recognized, then, that when the Committee

presents a list of the common needs of adolescents, it is, for the most part, merely classifying differing types of personal-social situations; a stated need, such as the need for health, is, then, a broad generalization, helpful for surveying the situation, but to be used only as a starting point for studying the particular students with whom the teacher is concerned.

The Basic Aspects of Living

The American youth must find his orientation in a complex, interdependent society which presents him with many and varied problems. In surveying the needs of the adolescent, the Committee has found it helpful to think of the involvements of youth in terms of four basic aspects of living: (1) Personal Living; (2) Immediate Personal-Social Relationships; (3) Social-Civic Relationships; and (4) Economic Relationships. The Study of Adolescents [1] indicates that these categories are psychologically valid and of undoubted significance for young people at the present time. The Committee makes no claim of finality for them. It is possible that other groups approaching the same problems might find a widely different classification more useful. Clearly these categories are not mutually exclusive, for complex human relationships do not lend themselves to neat compartmentalization. They are intended to serve as convenient centers of reference for identifying worthy interests and needs and for selecting and organizing appropriate learning experiences.

Personal living. In proposing this category, the Committee by no means intends to consider the individual apart from his environment. To attempt to do so would, of course, be absurd. But as the individual interacts with his environment he steadily builds unique characteristics which mark him off from other organisms; he defines his needs more accurately and gains insight into ways of meeting them—he develops as a *person.*

[1] See Preface.

Observation of the behavior of the adolescent in this aspect of living reveals at once some of his needs [2] as a growing, developing organism. He needs to attain a maximum of physical health and to be able to maintain it. He has evident need for assurance that he is developing normally and increasing in his ability to participate responsibly in adult affairs. He inquires into the nature of the world and attempts to build a world picture and find his place in it; these are indications of a need for understanding of the external world as it affects his philosophy of life. For his own satisfaction he needs to develop a variety of interests and to increase his esthetic appreciation of many types of experience.

In order to meet these and other needs, described and elaborated in a later chapter, the young person should develop the understandings, skills, and attitudes necessary for the maintenance of good physical and mental health. He should be led to expand his powers of appreciation and enjoyment. As a basis for the development of a philosophy of life he should be aided in understanding man's development of a conception of the external world—the history and nature of the physical universe, evolution of plant and animal life, and the conditioning effects of the environment—and of the nature and limitations of the scientific description of this world. He should be aided to develop a sense of the growth and effectiveness of knowledge through study of the major scientific ideas, their influence on thought and conduct and on the conditions under which men live together, and their bearing upon man's conception of his place in the universe.

In order to help the student meet his needs in this aspect of living, the science teacher will draw upon a number of the areas of pure and applied science—physiology, medicine, biology, geology, astronomy, physics, chemistry, upon the history and philosophy of science, and upon the resources of the science laboratories; he will also draw as much as feasible on

[2] For a discussion of the meaning of the term *need* as the Committee uses it, see p. 25.

resources outside the science field—the social sciences, philosophy, literature, the art studio, the workshop, the library—for, if science is to function effectively in the life of the whole youth, he must be able to see its interrelations with other areas of living.

Immediate personal-social relationships. By the time the individual reaches adolescence, he is involved in a multitude of relationships with persons in his immediate environment —his parents, his brothers and sisters, his schoolmates and chums. He has close contacts with persons of both sexes and with individuals both younger and older than himself. He also has many adjustments to make because of his relationships with culture groups whose manners and customs differ from his own. He is called upon to assume responsibilities within the family and within other face-to-face social groups —athletic teams, school clubs and societies, and the like. He develops an interest in the opposite sex, with all of its attendant involvements. A new world of contacts and immediate relationships with persons is opening to him, and he seeks to establish himself in it, a process that involves a gradual emancipation from home and family ties.

The primary adolescent needs in this aspect of living are two—the development of maturity as a participant in home and family life, and the development of maturity in relationships with age mates of both sexes.

The natural sciences may contribute to the meeting of these needs by helping the student to understand the way in which the applications of the sciences affect the family and the relationships of its members, and the rôle of sex in personal relationships under contemporary cultural conditions. They may also help him to acquire skills and special abilities that enable him to take part in the physical upkeep of the home, and to develop and enjoy family-centered interests.

Here the science teacher will draw particularly upon the biological sciences, anthropology, physics and chemistry, aspects of the social sciences, home economics, the school shops

and laboratories, the library, the art and music studios, and of course, upon many community resources.

Social-civic relationships. While the adolescent grows as a person and grows in the range, depth, and meaningfulness of his immediate personal-social relationships, he is simultaneously involved in relationships of a broader social character. There is, of course, no clear-cut line of demarcation between his contacts with the family group and those with the wider community and society, but a distinction between immediate personal relationships and wider social relationships nevertheless proves valuable for the purposes of education.

This distinction may be made in two ways. First, a line may be drawn at the point where the adolescent comes into contact with institutions other than the home. His participation in the activities of school, club, church, local community, and government may be conceived to be primarily social-civic in character, for though he may have immediate personal relationships within these institutions, through them he also acts with others for wide common purposes. Second, social-civic relationships require much greater use of general principles and conceptualization than do immediate personal-social relationships—a fact well illustrated by a comparison of the problems of getting along with people in face-to-face relationships with such social-civic problems as housing, community health and recreation, community planning, crime, divorce, and government.

In his social-civic relationships the adolescent needs social recognition, and he needs responsible participation in socially significant activities. This recognition and this participation he can gain through his membership in the institutional life of the school, local community, and wider community. The meeting of these needs requires growth in such characteristics as tolerance, coöperativeness, and social sensitivity, as well as growth in understanding of social forces and institutions and of methods by which desirable social changes may be realized.

The contributions of the natural sciences to education in this aspect of living are more important than is commonly realized. The student may be aided in developing a basis for understanding social problems. He can be helped to develop a sense of the interdependence of fields of knowledge and to become appreciative of the value of the experience of past generations. He can gain a conception of the growth of science and see the effects of its applications on social institutions. He can see the possible effects of greater use of the methods of science in the meeting of social-civic problems. These understandings are necessary to the equipment of a person who will be a bearer of the culture and a contributor to its development.

In dealing with this aspect of living, the science teacher must of necessity draw upon all the fields of the natural and biological sciences, and he must view them from the standpoint of their contributions to the enrichment of social life both now and in the past. He will also draw heavily upon the social sciences, literature, the arts, and language, in order to interpret fully the impact of science upon social welfare.

Economic relationships. Again it is pertinent to point out the close relationship between this aspect of living and those previously discussed. Even the immediate social life of the individual in the home has definite economic implications, and economic ideals and practices profoundly affect both the adolescent's personal philosophy and his development as a person. Social life and economic life are, of course, very closely related in modern industrial society. However, economic life in a narrower sense may be thought of as a separable area, and it is in this delimited sense that the term is here used.

This aspect of living includes the activities of the individual in the production and distribution of goods and services. Social changes have tended to remove the adolescent from contact with productive economic life. They have delayed his entrance into economic activity and surrounded it with difficulty and uncertainty; as a result, the vocational orienta-

tion of young people has become an educational problem. The adolescent has more responsibilities than ever before for the selection and purchase of goods; the secondary school must help him learn to use his intelligence as a consumer both now and in the future. Also, the adolescent is entering into his rôle as a citizen in a society characterized by growing industrialization, by associational activity on an increasing scale, and by more and more disposition toward the solution of economic problems by governmental means. The applications of the sciences to the use and control of energy and materials lie at the bottom of many of the processes of social change. The secondary school must help the adolescent to see the implications of the sciences for economic life, and it must help him to gain the understanding basic to intelligent judgment about such economic institutions as capitalism and other forms of economic organization, monopolies, collective bargaining, public ownership, money and banking, and domestic and international commerce.

Hence the principal needs of the adolescent in this aspect of living are emotional assurance of progress toward adult status through participation in adult economic affairs, vocational orientation, wise selection and use of goods and services, and participation as a citizen in the solution of basic economic problems.

The science teacher will draw in this area upon many materials hitherto not emphasized, for he must consider technology not only as it relates to industrial development but also as it affects human living. Materials of the social sciences, particularly economics and history, will aid in the process of orientation in this area as will the fine and industrial arts and home economics. The library, shops, and laboratories will also serve as resources.

THE MAJOR IDEALS OF DEMOCRACY

The purpose of general education as stated at the beginning of this chapter is phrased in terms of a democratic phi-

losophy and emphasizes effective participation in a democratic social life, together with the fullest possible realization of personal potentialities. But before such a conception can serve as a basis of reference for education, the major ideals of democracy must be made more explicit.

It is probably beyond dispute that the schools of any society reflect, by and large, the predominant ideals of that society—at least in so far as such ideals are understood and capable of being carried over into action. This idea has been well expressed as follows: [3] "Every system of thought and practice in education is formulated with some reference to the ideas and interests dominant or widely cherished in society at the time of its formulation." Dictatorships are undoubtedly in the best position to see to it that their educational systems reflect certain prescribed patterns of conduct and belief consistently and effectively. The government is not charged with propagandizing the schools because there is but one set of acceptable patterns and all citizens are expected to follow it without question.

In a democracy, however, the case is different. Ideals and patterns of belief and action evolve from the will of the people; consequently they are always in process of reconstruction and reinterpretation as the needs and conditions of the people change. This fact makes it impossible to set forth definitive formulations of ideal social arrangements; reinterpretation of both the ideals of a democracy and their embodiment in social institutions must come from the people as a whole. This being true, it follows that the program of the school cannot be set up with completeness or finality; it must be kept flexible in order to meet the changing personal-social needs of individuals and the changing demands of the social order. Furthermore, since democracy rests ultimately upon the intelligence of the common man, it follows that the

[3] *The Unique Function of Education in American Democracy*, Educational Policies Commission and the Department of Superintendence of the National Education Association, 1937, p. 6.

student must be given increasing responsibility for and aid toward reconstructing his own beliefs, attitudes, and plans of action upon the basis of his maturing intelligence. This implies that he must have a responsible share in planning the program of the school.

These considerations complicate enormously the problem of defining the purpose of the school in a democratic society and of formulating an appropriate and effective program. It is difficult to set forth the meanings essential to a working concept of democracy because of the dynamic character of the concept itself. Yet the schools have an inescapable responsibility to make it possible for young people to contribute effectively to the progressive refinement of the democratic way of life. Unless curriculum-making groups are willing to seek earnestly for the deeper meanings and implications of democracy, there is little hope that the school will have much direct influence in bringing about progressive refinement of democratic ideals and practices.

Acting upon this belief, the Committee presents its view as to the meaning of democracy and indicates some implications both for the school in general and for the science program.

In a recent article, John Dewey presents succinctly the broad idea of democracy which the Committee believes to be basic: [4]

> Democracy . . . means voluntary choice, based on an intelligence that is the outcome of free association and communication with others. It means a way of living together in which mutual and free consultation rule instead of force, and in which cooperation instead of brutal competition is the law of life; a social order in which all the forces that make for friendship, beauty, and knowledge are cherished in order that each individual may become what he, and he alone, is capable of becoming.

[4] John Dewey, "Education and Social Change," *Social Frontier,* Vol. 3, May, 1937, p. 238.

Max Otto puts the matter in a slightly different way: [5]

. . . Democracy is not a mere association of individuals whose purposes or acts are individualistic in the *laissez faire* sense. It is not even primarily a form of government. *It is an intelligent use of cooperative means for the progressive attainment of significant personalities.* Significant personalities cannot be unfolded from within; they must be acquired by individuals in union with other individuals intent upon a similar quest.

Analysis of the above quotations reveals at least three basic ideals of democratic living which, though intimately interrelated, are capable of isolation for the purpose of discussion and clarification: first of all, the fostering and development of distinctive personalities; second, "mutual and free consultation" in associated living, or the "use of coöperative means," instead of ruthless competition; and third, intelligence growing out of "free association and communication" as the basis of choice and action.

Obviously each one of these three aspects of democracy could be expanded to include the other two. For example, significant personalities can be developed only through free consultation and association with others and through the use of intelligence in the continuous reconstruction of experience. Free association in carrying out common ends and purposes implies a respect for the personality of those who are associated, and satisfactory outcomes of such association can only be secured when intelligence is placed above caprice, whim, or selfishness. And, finally, reliance on collective intelligence would imply action leading toward consequences satisfactory to all concerned: personality would have to be respected, and there would of necessity be free association and consultation. *To consider any one of the aspects of de-*

[5] Max C. Otto, "John Dewey's Philosophy," *Social Frontier,* Vol. 3, June, 1937, p. 266. (Italics in original.)

mocracy out of relationship to the others is to deal with an impossible abstraction.

On the other hand, to extend the meaning of any one to include everything which is meant by democratic living leads to vagueness. Consequently, the Committee chooses to discuss each aspect in turn.

Optimum Development of Personality

High regard for the individual is probably the most distinctive and pervasive characteristic of democratic living. In democracies, personalities are held to be precious, unique, and not capable of duplication. The optimum development of each individual, irrespective of birth, economic status, race, creed, or color, is to be encouraged and nurtured both because of the enhanced enjoyment of individual living which comes through full development of distinctive qualities and because of contributions which such distinctive qualities make to the common life.

To assert that human personality grows as individuals share in promoting common ends is merely to express the faith that democracy is the form of social organization best adapted to the full realization of the worth of the human personality. *But the development of human personality as a goal must not be confused with individualistic action* as a method for attaining the good life. Unrestrained individualism cannot be tolerated in a democratic program of living, for the living of each must be such as to allow others the realization of their potentialities. The disastrous effects of an outworn concept of individualism in a society which has become fundamentally interdependent have been exemplified as America has shifted from an agrarian to an industrial economy. This is not to argue for abandonment of the basic respect for personality so inherent in the American tradition, but rather that conditions for its realization must be continuously reinterpreted in the light of the changing situation.

This position is well stated in the following quotation from *Democracy in Transition:* [6]

. . . While the philosophy of individualism which emphasizes the worth of the individual and his right to an opportunity for the full development and free expression of his personality is as true as ever, and is still the *goal* of American life, individualism as a *method* of achieving the good life is no longer practical. . . . If we are to realize the goal of securing for the individual those conditions of life to which Americans have always aspired, we must abandon the philosophy and the practice of trying to achieve that goal only by individualistic means. Social responsibility and collective action for decent incomes, for security, for health, for recreation, for education, constitute . . . the only practical road to the goal of individualism.

It should be clearly understood that such social action is not a collectivism that crushes the individual, that elevates the welfare of the State above that of the individual, or denies to the individual his opportunity for free expression and the exercise of his initiative. It is, on the other hand, the only means under modern conditions through which the freedom and initiative and rights of the individual can be guaranteed and maintained. It is the pursuit of liberty, freedom, and opportunity by the cooperative method.

The concept of individualism is undergoing marked revision in the light of far-reaching developments in technology and their attendant effects upon human living. To some these profound changes mean that the individual is to be subordinated to society as a whole, as has happened elsewhere in the world. To others the changes mean that the "American Dream" of ever richer development of human personality has a fair chance of realization, if only the fruits of technology can be made available to all men. The Committee holds, as has been stated, that the ideal of maximum development of the individual should still be cherished as a

[6] *Democracy in Transition,* by a group of social scientists in the Ohio State University (New York, D. Appleton-Century Co., 1937), pp. 29–30.

goal, and that the schools should help to interpret its meaning in the light of rapidly changing social, political, and economic conditions.

Reciprocal Individual and Group Responsibility for Promoting Common Concerns

The development of significant personalities can, in fact, be achieved only through mutual sharing of interests and purposes; democratic participation in group life has its own distinctive characteristics and values which require special consideration. As Boyd H. Bode points out: [7]

> All . . . social organizations are means to an end, and this end lies inside the process of living together and working together; it is not located on a far-off mountain top created by an iridescent dream. The kingdom of heaven is within us, within the everyday lives of a toiling, sweating humanity.

To insure the satisfyingness of the associated life, the group, on the one hand, must accept the furthering of the concerns of its members as its highest value and must recognize that such an end necessitates the participation of the individual in determining policies that affect him, and the individual, for his part, must recognize that his own purposes cannot be considered apart from the needs and purposes of the group.

Increasingly the conditions of American life call for refinement of the concept of associated living: for seeing the significance of working together for the common good, for seeing one's own acts with a full sense of their bearing on the welfare of all, for seeing how not only advantage but responsibility is inherent in the relationship of individual and group, and for seeing how reciprocal examination and criticism of action are thus entailed.

[7] Boyd H. Bode, *Democracy as a Way of Life* (New York, The Macmillan Co., 1937), pp. 49–50. Quoted by permission of the publishers.

The Free Play of Intelligence

A third dominant ideal of the democratic society, fundamental to the refinement of democracy as a way of life, is reliance upon the free play of intelligence in solving problems of human concern—in contrast with the making of decisions on the basis of traditional beliefs, uncritical acceptance of authority, or blind impulse, or on the basis of one set of prescribed values uncriticized by comparison with the values of others.

In a democracy, institutions, policies, and programs are constantly in process of making. They are set up by the people themselves, rather than by some external authority or by some small group, and are subject to modification or rejection in accordance with the will of the people as a whole. It follows then that there must be no barriers to the free play of criticism and evaluation from every quarter; otherwise institutions and policies would no longer be subjected to critical scrutiny in the light of the values of the entire group. The alternative to reliance on collective intelligence in solving common problems is resort either to a philosophy of drift or to authoritarianism.

In its broadest aspects this ideal implies a disposition to abide by the results of collective thinking; to forgo personal bias and interest when these are ruled out by the facts; to go where the evidence points, irrespective of its locus of origin, or of authority, convention, or prejudice. Democracy rests upon faith in the intelligence of common men. Once this faith is destroyed, the alternative is some form of dictatorship, which means the destruction of democracy itself. The schools have never yet consciously and deliberately organized their programs in a way to encourage and promote intelligent action on the part of all people. Until this has been done, it is impossible to say that faith in the intelligence of the common man is unjustified.

The application of these ideals to the secondary-school program would cut very deeply. Each student would be studied as to his potentialities and nurtured in whatever unique way would build him to his highest stature as an individual. It would mean that students would be encouraged to work together at the problems facing them, of whatever kind; to carry this study wherever in the environment significant bearings appeared; to bring to bear the best that combined study could find; and to reach a conclusion which seemed to them justified in the light of the evidence. It would mean that no problem, no creed, no system of belief, could be walled off and kept isolated from thorough study, analysis, and evaluation. Within the limits of their maturity, students would be encouraged to formulate their own outlook on life, scrutinize it in the light of the best that is known, and reconstruct it in the light of new evidence.

Out of the welter of conflicting ideals and practices which beset adolescents on every hand, they would seek to weave unity and consistency into their lives. From continued study of problems and continued generalization of results, they would increasingly learn methods of intelligent search, standards of evaluation, and dissatisfaction with shoddy procedures; they would come to build reliance on intelligence. And the school would be committed to the task of helping them in the process rather than determining their beliefs and patterns of conduct for them.

The acceptance of this point of view would mean that the organization and administration of the school would be directed toward the fullest possible exemplification of these three interrelated ideals: the school would be organized in a way to promote the maximum growth of personality of teachers, pupils, and all members of the school community; to provide for the fullest possible sharing of interests and concerns, with group responsibility for their satisfactory realization; and to promote the ever widening use of intelligence in all of its activities and the free play of opinion to

this end. The out-working of the point of view would reach into pupil-teacher relationships in the classroom and into the face-to-face relationships of pupils. Not only would it have important bearings upon method and procedure; it would provide, in addition, direction for the curriculum in all areas. Later parts of this report indicate how, in particular, it would affect the science program of the school.

PERSONAL CHARACTERISTICS ESSENTIAL TO DEMOCRATIC LIVING

Up to this point the Committee has been mainly concerned to outline the major ideals of democracy as an indication of the general direction it believes the secondary school should take. But in order to promote a democratic group life it is necessary to have individuals with characteristics appropriate to its pursuit; it is necessary to decide, at least in a general way, the kind of behavior to be fostered in adolescents as they grow toward mature participation in the common life. To this end the Committee proposes to set forth some of the characteristics which seem to be desirable from the point of view of development of personality and at the same time essential to democratic living.[8]

The list is by no means complete. And it must be kept in mind also that these characteristics are not mere "abstract absolutes," valuable as ends in themselves. "Coöperation" may be practised with a band of racketeers or "reflective thinking" used in planning a bank robbery, and the more the individual cultivates these characteristics with reference

[8] Parenthetically, the ideals of a democratic society and the characteristics of personality implied by them might well be called needs. However, for purposes of clarity the Committee considers it wise to distinguish these from needs as used in the above discussion, for two reasons: first, to differentiate from the common needs of adolescents existing as going concerns in the lives of boys and girls, irrespective of the direction the meeting of these needs should take if they are to foster democracy as a way of life; and second, to avoid the danger of listing as needs certain ideals and values of adult democratic society which at any given time may not be identifiable as biological tensions in boys and girls.

merely to such isolated aims the greater menace he is to society. But as the Committee sees it, none of these characteristics is justifiably to be sought in isolation; always they are relative to the constituent ideals of shared democratic living. Thus "coöperativeness" is only to be encouraged when it furthers respect for personality, shared responsibility for common concerns, and the like. Always it must be interpreted in the light of the complete personal-social situation in which it functions.

The interrelatedness of these characteristics must also be stressed. They do not exist as independent entities which can be singled out and cultivated separately; they are distinguishable aspects of the total personality of the individual, and each enters into and remakes the others. As the individual seeks to achieve unity and consistency of behavior, these qualities give character to his pattern of living.

It should be kept in mind also that there is no single pattern of life which fits all individuals. Young people differ in their capacities, interests, and needs, and it is neither feasible nor desirable to expect all to develop the same types of personality. On the contrary, there are an indefinite number of individual patterns, and to all of them the broad purpose of general education can be definitely related, though with differing application to each individual.

Social Sensitivity

This characteristic of behavior has been described as "an awareness of, and responsiveness to, social and human phenomena." [9] But in order to be helpful, the concept must be broken down into the more specific attitudes and abilities that characterize the socially sensitive person. These are perhaps best indicated by an analytical description of how such a person functions,[10] which may be summarized as follows:

[9] Hilda Taba, "Social Sensitivity," Progressive Education Association, Evaluation in the Eight Year Study, *Bulletin* No. 6, University of Chicago, December, 1936 (originally published at Ohio State University).

[10] *Ibid.*

a. He enters appreciatively and sympathetically into the lives of others. His concern should extend beyond the boundaries of the particular social group with which he is primarily identified and should extend, as his contacts broaden, to ever widening areas. The ideal, of course, is to develop individuals who recognize their kinship with the human race as a whole, so that human suffering in China or Ethiopia becomes their active concern and so that they cherish human achievement, even remote in space or time, as a contribution to present-day living.

b. He is sensitive to the effects of his own actions as a citizen, producer, consumer, upon the welfare of others. This necessarily involves the disposition to consider his own acts in terms of all their foreseeable consequences to other people. Again this is a question of continuing growth, but the socially sensitive person has disciplined himself to see as far as possible and always to widen the area of his vision.

c. He is willing to take measures counter to his own immediate comfort, or the comfort of the group with which he is immediately identified, for the sake of a broader social good.

d. He looks upon social maladjustments as problems to be solved through the application of intelligence, rather than as evidence of the perversity of an unalterable human nature. Sensitivity here is to the malleable elements in situations and to evidences of the way people respond with better adaptations when the values in doing so can be made apparent. Wide historical perspective should aid here.

e. He evaluates all measures, including the economic and political, upon the basis of all the human values involved in the situation. For example, it has been shown that the emerging concept of democratic living requires reconstruction of the concept of individualism. Retention of the older conception as a basis of operation in society—whether it be embodied in law or otherwise maintained—is antithetical to the highest good of all. The person who is socially sensitive recognizes this and acts accordingly.

The school can do much to promote social sensitivity on the part of students. It can organize its activities in such way as to provide constant opportunity for effective social

participation in the life of the school. It can make the community a laboratory for the study of social problems, and to a limited extent students can participate in community activities. The school can encourage and help the student to study the effects on others both of his own actions and of the actions of policy-making groups inside and outside the school. The science teacher can help students to become socially sensitive by organizing his activities so as to promote free interplay of ideas. He can also help students to see the past and continuing rôle of science in bringing about better human relationships.

Tolerance

Clearly akin to social sensitivity is the increasing disposition and ability to appraise sympathetically, in terms of their unique contributions to the enrichment of the common life, those points of view, customs, and traditions which differ from one's own, or from those of the group with which one is identified.

This characteristic of personality is distinctly democratic in character, for only among peoples dedicated to the full and free development of personality through associated living is the individual encouraged to respect viewpoints which differ materially from his own. In a really democratic group life the contributions, for example, of different racial or national groups are cherished, out of the principle of respect for personality as well as for their contribution to the progressive refinement of individual and group living. "Elasticity of the emotions and the intellect" not only makes possible a sympathetic understanding and appreciation of honest differences, but makes possible also the utilization of these differences in enhancing human values. The individual who is achieving such elasticity is in process of achieving a genuine understanding of the meaning of democracy, is growing toward maturity of participation in democratic living.

Exercise of tolerance does not, however, mean a *laissez-*

faire attitude toward any and all ways of believing; it does not mean absence of standards, preferences, considerations. The criticized value in which tolerance is rooted is the promotion of qualities and conditions that add to the variety and richness of human living and that make possible the cultivation of ideas for its improvement. On this basis, it would be impossible to condone tolerance of traits or practices that militate against this criticized value—ruthlessness, dogmatism, cruelty, injustice, lying, suppression of just civil liberties, exploitation of human lives. Exercise of tolerance has, therefore, not merely the negative aspect of noninterference but also a positive aspect which imposes an obligation to maintain actual means to discernment, criticism, and thoughtful variation. Stated from a different angle, tolerance is by no means an "absolute value"—like all other values, it must be weighed in connection with other claims for consideration.

The science program that emphasizes only the weighing of quantitative data and the solution of problems involving only quantitative relationships will do little toward developing tolerance. Once the method of the scientist is seen in its broader aspects and science is regarded as an area with significant implications for enriching and enhancing human values, the application of this concept of tolerance becomes apparent. The very method of the scientist, which emphasizes open-mindedness, tentative judgment, and the experimental attitude, is the stuff out of which tolerance is made. The individual who is dedicated to the method of science cannot adhere dogmatically to a narrow range of considerations and thus run the risk of ignoring relevant data in arriving at conclusions. Honest attempt at sympathetic appraisal of other points of view is essential to his integrity.

Coöperativeness

As members of an industrial culture, the American people are undoubtedly becoming more and more interdependent.

This, as has been pointed out, calls for rather drastic modification of the prevailing concept of individualism. The trend toward a growing collectivism means that, if the democratic tradition is to be maintained, new and more effective means of working together must be devised. As Edmund Day has pointed out, one of the basic ideals of democracy has always been [11] "the settlement of controversies between groups or classes of individuals by peaceful means, through resort to discussion, persuasion, the ballot, acceptance, and appraisal." But coöperation means much more than the settling of controversies; it means a vital sharing of interests, an active concern with promoting the values of others, and a working together to promote more wholesome human relationships. It is the business of the school to develop individuals who have not only the disposition but also the understanding and ability to put this ideal into more general practice.

The Disposition and Ability to Use Reflective Thinking in the Solution of Problems

This characteristic is peculiarly necessary in a democracy, where each is expected to take part in policy-making and to direct his own life, both in terms of his own enjoyment and at the same time in consideration of the effect on others.

In analyzing the process of reflective thinking as it goes on in the process of living, several stages may be distinguished. These have much in common with analogous steps in the solution of laboratory problems, but include considerations of human value in addition.[12]

a. *Sensing a need in the situation* (a condition to be improved, events developing less fruitfully than they should, a violation of human values, a problem calling for solution)
b. *Analyzing the situation and locating the problem with sufficient accuracy to attack it*

[11] Edmund E. Day, "Basic Responsibilities of General Education in America," *Educational Record,* Vol. 17, Supplement No. 10, (October, 1936), p. 18.
[12] The process of reflective thinking is discussed in detail in Chapter VII.

c. *Formulating and refining an hypothesis to act upon* (In addition to the usual considerations of laboratory thinking, there must be taken into account here the effect on others, feasibility of application in view of the fact that other people are enmeshed in the situation, and the like.)
d. *Acting on the most promising hypothesis* (Until this is done there is, in a life situation, no real test of the adequacy of the thinking; only when the hypothesis is acted out do the consequences begin to manifest themselves, the shortages and strengths of the thinking to be apparent. And for the most part the process is more irrevocable in life; the consequences enter for good or ill into the stream of events; they are there to stay.)

Science teaching has much to contribute to the improvement of reflective thinking in personal and social living, and its responsibilities here should be faced. Science instruction too often confines the application of the scientific method to the more abstract problems of the laboratory, with definite loss as regards living processes. For example, the first phase of the process, "sensing a need," is, for the most part, short-circuited for students, and thus little of value is learned for application to life problems. It is highly important in personal and social living to be able to "sense situations" (to realize that a condition exists which might be bettered, that events are developing less fruitfully than is desirable, that a problem has arisen) and to define the problem with sufficient accuracy to attack it. Often the school does little to help the student learn such sensitivity because "problems" are "given" to him—the problem is isolated and stated in a way to allow no practice in this important respect.

Similarly with the other phases of the process: in life, analysis and interpretation, gathering suggestions, formulating hypotheses, and elaborating these into a plan of action are different here from the laboratory situation—life processes tend to be more complicated, less certainly manageable; other people must be taken into account. And throughout the

process, from the first stage of "sensing" through the last stage of application, relations with others are usually involved. Cooperative thinking almost certainly provides richer suggestion and better results. But though the procedure with life problems must be more complex there should be no divorce from scientific methods. Unless this fact is pointed out and pains taken to indicate differences and similarities of procedure, an unfortunate compartmentalization may result in the student's thinking.

Students should likewise be helped to see that the phases of thinking indicated do not necessarily follow in the order outlined, and to see also that all of the steps may be followed over and over in working at a problem, for problems arise within problems—a new sense of perplexity presents itself; new hypotheses and further testing become necessary. And a problem counted relatively "solved" may later need to be reopened as new evidence appears or the situation changes. What this means is not a repudiation of the values of reflective thinking or of scientific method, but that thinking and testing in action go on indefinitely with regard to most areas. To think without trying out the thinking in action would be insufficient; to act without continuing the scrutiny of thinking would be dogmatic and stupid.

Life is, in a sense, a "quest for certainty." In a culture characterized by rapid change, one can never be sure that facts yet to be discovered will not prove a given judgment or hypothesis wrong. This is especially true in the area of social problems, although even the scientist, in most cases, must be satisfied with tentative conclusions. The history of the sciences is rich in illustrations of men who acted upon the "best" hypothesis and discovered, as the result of action, the necessity for drastic revision or complete abandonment of the original hypothesis.

In stressing reflective thinking as "the method of intelligent learning" no gratuitous assumptions are here made concerning mental discipline or the transfer of reflective

thinking from situations in which it is learned and practised to situations that are quite different. Reflective thinking must, for the great majority of people, be learned and practised in connection with the solution of social problems if it is to be applied by them to such problems at a later time. Cultivation of reflective thinking requires repeated and varied experience in critical analysis of manageable material, in the formulation of appropriate inferences, in the interpretation of data, in the application of principles, and in the testing of hypotheses.

The acceptance of responsibility by the science teacher for the cultivation of reflective thinking has obviously important implications for both content and method. It calls for an emphasis upon the problem approach—and the problems must be genuine for the pupil, rather than merely important to the teacher. It means continuous opportunity to arrive at understandings through thinking, rather than through memory, and opportunity and encouragement to apply such understandings to new situations. It also involves laboratory experiences which are exemplifications of the method. And the science teacher should seize every opportunity to help the student see how reflective thinking, as practised in the science laboratory, is applicable to other areas of living.

These considerations suggest that through his science experience the student may come to appreciate the value of reflective thinking, to see how the method has enabled man to banish many unreasonable fears and superstitions, better to control his life and better to attain his ideals. It is hoped that through the development of such understandings the student may develop both ability and determination to apply reflective thinking to his problems in every pertinent area.

Creativeness

This characteristic is obviously closely related to the thinking process. However, the two are not to be completely iden-

tified. By creativeness is meant the tendency of the individual to make novel adjustments. It may also be thought of operationally as the synthesizing of previously unrelated elements of experience into a dynamic, unified whole. Undoubtedly all normal human beings possess this quality to some degree. To use John Dewey's illustration, when the child *learns* that the reaching for and grasping of the candle flame is associated with the pain which results, he has had a creative experience. In like manner the discovery of the law of the pendulum by Galileo, through watching the swinging chandeliers in the cathedral, was a creative act. When the artist succeeds in giving expression to an idea on canvas, he has illustrated this unique quality of human behavior. Whenever a person analyzes the elements and potentialities of a situation and uses his grasp of it in such way as to bring clarity out of confusion, to make a better situation from a worse one, to remake what is into a more satisfying state of affairs, there creativeness exists.

The concern here is not with the psychological explanation of creativeness. Obviously, it involves a "leap in the dark," a "hunch," or in more conventional terminology, an hypothesis. Though the exact nature of the mechanism by which human beings make this leap is not known, the behavior itself is a common fact of human experience. Some have been accustomed to think of creativeness as a quality to be expected in only the few; the Committee believes, however, there is abundant evidence that in an environment rich in possibilities, all sorts of individuals (except actual idiots) can grow markedly in ability to deal with materials in this fashion. The Committee also holds that in a democracy where each is to share as far as possible in determining policies that affect both him and others, this quality should be developed in all students to the fullest possible extent.

What can the school do to help the adolescent develop his creative possibilities? Primarily, it must try to understand the drives that are, at the moment, giving character to his

behavior. It must, in other words, take stock of his present needs and interests and encourage him to achieve their satisfaction in ways that are as full, as varied, as significant as possible. For example, if he shows unusual interest and ability along certain lines, the school can help him to engage in activities that reach out beyond present experience into uncharted seas, rather than hold him to routine. It must cultivate an atmosphere in which the devising of new and better ideas and procedures is encouraged, rather than one which conveys the feeling that it is somehow not quite right to differ from accepted and established ways and that variations interfere with smooth working arrangements. Above all the school must refrain from doing the student's thinking for him, but must instead stimulate him to the most fruitful endeavor along lines that grip him.

Application of the concept of creativeness to the field of science teaching is made in later chapters. At this point it is perhaps only necessary to state that the stimulation and development of this quality demands, among other things, a full recognition of and provision for the cultivation of the science interests of adolescents; a type of laboratory experience that is an adventure into the unknown, rather than the routine following of directions; and constant practice in discovering new understandings and applying them to novel situations.

Self-Direction

An important responsibility of education in a democracy is to promote to the optimum the student's ability to plan and direct his own life. In doing so, the use of intelligence is, of course, central. For cultivation of self-direction does not mean that the student is to be free to do as he pleases, but rather that he is to be helped to attain intellectual independence through the exercise of intelligence in what he does from day to day. A sane and workable concept of freedom involves both the opportunity and the disposition to as-

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sume full responsibility for the consequences of one's acts. That individual is free who has disciplined himself to act through intelligence rather than through caprice or selfishness. From this point of view freedom is not a gift but is built up through the use of intelligence.

The development of this characteristic has important implications for school practice. The school environment must be organized in such way as to give the student increasing control over his experience. In all of his life situations which involve the making of choices, he must be encouraged to take responsibility and helped to make his choices wisely. As he grows more mature emotionally, socially, and intellectually, these situations will necessarily involve more complex relationships. The teacher will frequently be called upon to study the emotional blockings which prevent the use of intelligence and to help the student to overcome the inhibitions and fears which are interfering with his growth. Careful guidance of the student's experience is called for, instead of the constant imposition of adult plans and points of view.

Work in the science area offers no unique means of achieving this characteristic; it is rather a general responsibility of teachers in all areas. Clearly, however, the methods used in teaching science may aid the pupil's growth in self-direction, or they may retard such growth. Individual projects, with responsibility for planning and carrying through the project to completion and for evaluation of one's performance in it are desirable. Laboratory work is valuable to the extent that it gives the student a chance to exercise judgment in the solution of problems. The important thing is to provide at every point for the optimum use of the student's intelligence in the responsible direction of his experience.

Esthetic Appreciation

Appreciations are taken to mean an emotionalized response characterized by enjoyment. To appreciate deeply means to cherish, to esteem, to prize. Its presence in experi-

ence marks the difference between mere understanding and a recognition of qualities which are appealing and enjoyable. The enjoyment may be a very simple response to something like a landscape or a game, or it may be one that relies upon a body of experience or knowledge for its value, as in the study of painting, geometry, geology, and architecture. Enjoyments may emerge from reading a poem, seeing a piece of sculpture, watching a machine, working through a demonstration in mathematics, making an experiment in the laboratory, solving a problem in human welfare, or observing a sunset.

In addition to the quality of enjoyment, esthetic appreciation also carries with it the idea of *appraisal.* Some enjoyable things are of more value socially and esthetically than others, and thus the cultivation of appreciation involves not only enjoyment but also the development of personal standards, tastes, and judgments concerning the value of a given experience. This is but another way of saying that appreciations have both intrinsic and instrumental values.

The behavior of a person who is growing in his ability to enjoy a variety of things and to appreciate them deeply is characterized by an increasing zest for living and by higher standards of value, both of which contribute to the richness of experience, thereby making for deeper and keener enjoyments.

The science teacher can do much to help his students develop and enhance their enjoyments. If he is sensitive to what is significant *to them,* he can help them see meanings in life about them which will add greatly to the richness of their day-to-day experience. Many enthusiasms and enjoyments students will "catch" from him as he opens up areas meaningful and truly satisfying to him. In addition he should, wherever possible, cultivate whatever shreds of interest he discerns in his students and help these interests to develop into something which they find richer and more satisfying.

IMPLEMENTING EFFECTIVE SOCIAL PARTICIPATION AND THE REALIZATION OF PERSONAL POTENTIALITIES WITH UNDERSTANDINGS

In order that the individual may participate effectively in a democratic society and realize his potentialities within that process, it is essential that he understand the society in which he lives, the factors that are strategic in it, and the processes by which it operates and changes. It is not only that realization of the democratic ideals requires certain personal characteristics on the part of the individual; these characteristics are ineffective unless they have specific reference to the situation in which they are to make themselves manifest. Likewise, it is impossible to participate effectively in a society without understanding the crucial issues before it, their bearings upon the individuals within it, the alternative ways in which they may be resolved, and the like. The individual acts neither upon his information alone nor upon his characteristics alone. Each of these colors the other, and both give direction to his conduct. In brief, he acts with understanding.

This is nothing more than to say that characteristics of personality are meaningless and that effective participation is impossible except in some context. But it does imply that the individual growing up in a complex and changing society must understand his world. Otherwise, all else in his education is futile.

It means further that there are certain things about this world that it is more important for him to understand than others. They are areas in which democratic ideals are threatened or areas in which they may soon be more fully realized, or where the realization of potentialities of the individual stands in particular jeopardy or promises especially rich fruition.

For this reason the processes designed to further purposes of education must give rise to certain understandings, simul-

taneously with the development of characteristics of personality essential for participation in a democratic society. Understanding, in large or small measure, is essential to the building of each of the personal characteristics set forth as desirable. With social sensitivity, for example, the relation is obvious. Tolerance (in any but a *laissez-faire* sense which indicates equal receptiveness to all ideas and behavior alike) requires understanding, both in order to appreciate the values in heterogeneity and to recognize when deviation is of the sort to shut off rich living and critical thinking.

On the other hand, as the other characteristics of personality mentioned above are built, understandings increase in range and depth of meaning. Social sensitivity is prerequisite to many understandings essential to effective participation in democratic life; similarly with tolerance. And the same reciprocal relationship holds true in the development of understandings and of each of the personal characteristics mentioned above.

Clearly understandings have a central place in education. To secure them is, however, not so simple as the imparting of information. Because many people confuse the two and in consequence overstress the narrowly informational aspect of education, the Committee prefers to set forth first the framework in which we believe information should operate. Having made this distinction, the Committee wishes to state its predilection for educational procedure which puts its effort into the building of "understandings," as distinguished from mere information. *The term "understanding" is here used to denote a major conception so grasped as to illuminate its connections with related conceptions and to result in significant changes in the individual's behavior.*

A principle, for example, becomes an understanding for an individual only when and as it throws new light for him on a group of relationships not previously sensed and so brings about a reorganization of his behavior. Thus mere memorization of the statement, "Natural energy can be con-

trolled and used for the purposes of economic life," does not constitute an understanding. To be an understanding in the sense in which the Committee here uses the term, the principle would have to possess sufficient meaning to the student to enable him to comprehend its implications for human welfare and to apply it to the interpretation of new situations where it is pertinent.

Obviously the richness of meaning which is part and parcel of an understanding will vary with the person and with the range and depth of the experiences that have contributed to its building. Thus the concept, "The earth is very old," constitutes a very different understanding for the child and for the geologist. For the child it may mean only that the earth is older than mother or father or the house in which he lives; for the older adolescent it may mean, among other things, a reconstruction of previously understood accounts of creation; for the geologist it will undoubtedly serve as a vehicle for a systematic organization of much of the accumulated race experience concerning geological eras. Understanding of an important conception can never be complete; new experiences bring about new syntheses as long as the conception functions. Exactly how far the science teacher should go in helping to develop richness of understandings cannot be answered in advance. It depends upon the maturity level of the student, his present needs, and the nature of the understanding itself. The point to be emphasized is the changing, growing, and dynamic character of understandings.

THE RELATION OF SCIENCE TEACHING TO GENERAL EDUCATION

The science teacher has probably been bothered by the fact that so little space has been given in this chapter to the actual problem of the science curriculum. The Committee has purposely avoided dealing here with science materials except by way of illustration, because its aim at this point is

to develop a "frame of reference" to be used in orienting education in general, in defining the function of science teaching in connection, and in evaluating materials and methods in the field of science teaching.

In accordance with the development of this point of view the science teacher will ask such questions as the following about a proposed learning activity in his program:

1. How does it help the adolescent to meet his personal-social needs in the four categories proposed by the Committee?
2. How does it tend to further realization of the ideals of the democratic society?
3. How does it help the adolescent to develop the characteristics of personality essential to effective living in such a democratic society?

It is hoped that in answering these questions the science teacher will be helped to organize his program so as to utilize to the fullest the contributions of science to human living.

Part II

TEACHING SCIENCE TO MEET THE NEEDS OF ADOLESCENTS IN THE BASIC ASPECTS OF LIVING

Part I of the report proposed a threefold classification to be used in studying the needs of students; Part II implements this analysis by exploring the possibilities in materials and methods of science for meeting each of the four types of need. To this end Chapter III of Part II deals with the *Personal Living* of the adolescent; Chapter IV with his *Immediate Personal-Social Relationships;* Chapter V with his *Social-Civic Relationships;* and Chapter VI with the problems which grow out of his contacts with *Economic Relationships.*

Chapter VII deals with the problem of developing skill in reflective thinking and building the tendency to use it in the solution of problems. Since instruction in the sciences is considered by many teachers to be particularly valuable in connection with this important characteristic of personality, it seemed wise to single out reflective thinking for special treatment, even though each of the previous chapters of Part II refers frequently to the development of all of the desirable characteristics, this included. The treatment of this problem consists in the main of an analysis of the process of reflective thinking and illustrative material on the function of science teaching in connection.

THE SCOPE OF CHAPTERS III–VI

Each chapter presents first an overview of the area under consideration, enumerates some of the most important needs of adolescents within it, and then proceeds to discuss the major understandings and other learning products held to be significant in meeting these needs and developing the characteristics of personality desirable in democracy and in the contemporary culture. A number of learning activities that might help in the process are then suggested; they are intended only to illustrate broad categories or kinds of activities, for the particular activities pursued would, of course, vary from group to group. Each chapter also raises a certain number of problems and issues and suggests various alternative solutions. Finally, a partial and tentative list is provided of generalizations of the more specific sort, to illustrate for the science teacher the *kinds* of information that, if used intelligently and in consideration of the need of the particular students, may contribute to rich and fruitful understanding.

Since each chapter was prepared by a sub-committee, differences in style, treatment, and detail are to be expected. The Committee made no attempt to secure uniformity of treatment, except in so far as indicated above.

These five chapters are not intended to provide a definite organization for all programs of science instruction at the secondary level. It is hoped, however, that the material they include will be suggestive to each teacher in rethinking, enriching, reconstructing his own program, and in evaluating it in terms of the reconstruction and refinement of the democratic way of life.

The bibliographies appended to each chapter are intended for the teacher's use in familiarizing himself with the points of view suggested. The references represent differing and sometimes contrasting positions, to encourage the reader to arrive at an independent judgment on controversial issues.

THE USE OF THE TERMS "GENERALIZATIONS" AND "INQUIRIES"

Throughout this part of the report the Committee has made use of the term *generalizations* to represent *understandings.* The discussion in Chapter II has sought to make it clear that understandings are dynamic, developing learning products that involve significant changes in pupil behavior. Thus to develop the actual understandings in the field of science would, for any given individual, involve a study of the growth of individual experience with all of the related learning products (for example, attitudes, general and specific habits, and the like) which are inevitably bound up with the verbal aspects of an understanding. It would be impossible, of course, to state all the factors of cause and effect that enter into such a learning experience. The Committee therefore makes use of the term *generalization* to denote the purely verbal statement of a *potential* understanding.

Thus the statement, "The production of the various kinds of goods needed by modern society depends on the use and control of a wide variety of materials," is a generalization. The discussion that accompanies this statement presents some of the relevant facts and information, the possible attitudes involved, and some suggestions of possible learning experiences which would be helpful in developing a genuine *understanding* in the area of this *generalization.*

It must be reiterated then that when the Committee presents (Chapters III–VII) lists of *generalizations,* such statements are really only *potential understandings* which may result from certain kinds of student experiences. *They must not be thought of as science content to be memorized.* The test of effective learning of these generalizations is found, not in the ability of the student to verbalize them, but rather in the changes in behavior resulting from them.

Many attempts have been made to classify generalizations.

For example, in an earlier version of this report the Committee proposed a twofold classification, as follows: (1) factual generalizations, which are based on well-established facts, facts not questioned by scientists—these do not contain a judgment of value—and (2) philosophical generalizations concerning the nature and results of science as a whole or its methods. Clearly the generalization that "coal and petroleum fuels are our present chief sources of energy for industry" is much more "factual" in character than certain others, for example, the following: "Man's moral ideas have been influenced by and have influenced technical inventions and processes." Science understandings may also be based on "pure science" generalizations, or on interpretative ones.

Though such distinctions may have certain values, the Committee makes no important use of them. Since the particular meanings that are built up around a given idea vary significantly with individuals and with maturity levels, these distinctions become blurred or even meaningless in terms of changes in the student's experience.

The term *inquiries* is used as an alternative to *generalizations* to denote problems or questions for which no single solution or answer acceptable under all conditions can be given—an area in which no adequate generalization can be made. The interrogative form is used for such problems as, for example, "Is there a conflict between science and religion?" Since honest and well-informed people disagree as to the answer to this problem, it seemed unwise for the Committee to attempt to state a generalization in relation to it. It would be feasible to state a number of *possible* solutions in the form of generalizations, and to make it clear that the teacher's responsibility is to deal fairly with the alternatives, permitting the student to select the one which seemed best to answer his questions. Undoubtedly if this issue arose in the classroom, the teacher would, with the help of the students, set up competing hypotheses in the form of possible generalizations.

Since the hypotheses advanced would vary with the locality, the cultural backgrounds of the students and their maturity, the statement of the problem in terms of an inquiry seemed the most satisfactory way of dealing with issues of this sort.

III

MEETING THE NEEDS OF ADOLESCENTS IN THE AREA OF PERSONAL LIVING

INTRODUCTION

The Scope of Needs in This Aspect of Living

Chapter II indicated the range of meaning which the Committee proposes to give to the term *personal living*. Summarizing, it may be said that the adolescent has five major needs in this aspect of living:

1. THE NEED FOR PERSONAL HEALTH
2. THE NEED FOR SELF-ASSURANCE
3. THE NEED FOR A SATISFYING WORLD PICTURE AND A WORKABLE PHILOSOPHY OF LIFE
4. THE NEED FOR A RANGE OF PERSONAL INTERESTS
5. THE NEED FOR ESTHETIC SATISFACTIONS

Also in Chapter II a conceptual basis was laid for the planning of science teaching as a part of general education. The task of this chapter is to discuss meeting the needs of adolescents in the area of personal living in terms of the criteria there proposed, and so to suggest ways in which science teachers may make their work in this area more effective.

THE NEED FOR PERSONAL HEALTH

It is immediately obvious that an individual's effectiveness and happiness are dependent in large measure on his physical health and the related aspects of mental health. Hence no one will question the desirability of attaining and maintaining personal health at the highest possible level. The require-

ments of the individual in attaining and maintaining his health include an interrelated body of habits, attitudes, and factual information (plus actual physical activities and satisfactory living conditions); this section is concerned with the part teachers of science can play in such attainment, and with what they can do at the same time to help young people develop certain characteristics of personality.

Physical Health and Mental Health

The important connections between physical and mental health may appear to be thrust too much into the background by a major emphasis on science generalizations whose understanding is relevant to helping the student maintain his physical health. Yet these connections are so close that no real distinction between physical and mental health is here proposed; the suggested contributions of natural science to the maintenance of physical health may be taken as contributions to the most fundamental aspects of mental health. For why should physical health be good? Is it not almost entirely because people *feel* better when they are healthy, because they believe it is better to be wholly alive than half alive?

Yet this does not mean that mental hygiene, as a relatively distinct discipline, is without relevance for the science teacher who is genuinely concerned with helping students maintain physical health. For the sensitive teacher will find, as teachers have found in the past, that many students will not cease to worry, will not be able to change their habits, will not be able to apply to their own lives the rules they have learned, even when they are able to prove that they have mastered the intellectual content of these rules completely. If such a teacher accepts the view of mental hygiene summarized in Chapter VIII, he will readily understand that the behavior of these students is symptomatic of conflicts the causes of which go much deeper than mere "inability to control themselves."

The student may know all there is to know about sufficient rest as a necessary condition for good health, for example, and

still consistently refuse to get enough sleep. The science teacher must realize that he often has good reasons for this. After the mechanical or "rational" possibilities (such as poor sleeping conditions or excessive fatigue) have been eliminated, it may often be found that he is trying to be grown up, that he is protesting against a diminution of his rightful importance, that he is overburdened with responsibilities, or that he is unable to cope in some other way with a genuine or fancied inferiority.

In short, the teacher who has accepted the point of view of this report will realize that all such actions may be symptoms of rather deep-lying problems. Inability to apply the most obvious rules of diet, excessive drinking, refusal to accept the applicability of normal variations to one's own physical characteristics, consistent disregard for health in general, and overanxiety about it may all indicate profound conflicts in the personality. Such conflicts cannot be resolved by appeals to the student's reasonableness, nor is it generally true that the unaided teacher can uncover the particular conflict and its causes. The advice and coöperation of an experienced guidance worker are strongly recommended wherever these services are available.

Considerations of mental hygiene will also affect the way in which the teacher goes about helping students develop effective understandings in the area of health—both in class and with individual students. He proceeds with caution in the discussion of variations in physical characteristics when he recognizes that adolescents in general are likely to be overanxious about their weight, their pubertal development, and the like. In approaching the topic of venereal diseases he takes account of the fact that irrational and exaggerated fear may thwart the natural curiosity of adolescents and thus warp their attitudes toward sex.

In dealing with the adolescent who insists upon smoking or drinking, he is aware both of the social pressure from within the student's own age group, and of the fact that the adolescent

is very much engaged in growing up. The student's interpretation of what growing up means may often be superficial; he often thinks that he is grown up as soon as he has acquired all the external habits and manners of the adults he knows. Adults, on the other hand, are likely to feel that the adolescent may not indulge in adult manners until he has shown himself grown up in other ways. Teachers may want to encourage parents to consider the grounds on which they forbid their children to smoke or drink—to help them become aware of how little justification there is for any statement of the harmful effects of these drugs when consumed occasionally and in small quantity, and of the fact that parental injunctions are often based on a morality alien to the adolescent, since his own group does not frown on these manners.

Thus, even where conflicts are not profound and the services of a guidance worker are not required, considerations of mental health affect the teacher's procedure at every point as he works at meeting the need for physical health—his approach to topics and to the class, his relationships with individual students, and his contacts with parents. Primarily, they imply a responsibility on his part to know his students, to be sensitive as to the adequacy of the understandings they are gaining as individuals, and to deal with them accordingly in order that health learnings may prove actually effective in the attainment and maintenance of health, both physical and mental.

The Kinds of Health Knowledge Important to the Adolescent

The criterion for the selection of teaching material is not the effectiveness with which it summarizes the known body of knowledge in the field but rather the degree to which it affects the adolescent's choices, actions, and attitudes. A large amount of material commonly included in biology courses for the sake of logical completeness is frequently justified in the name of "health education," when it is patently irrelevant in that connection; likewise the logic of the usual course in the

subject-matter of biology omits other material that needs to be brought in because it is relevant. Similar comment applies to the present content of science courses other than biology and to adolescent needs other than that for physical health. Of course some types of information about the body which are not pertinent to considerations of health may be of value to the adolescent in meeting, for example, his need for a world picture, in coming to see himself as part of the biological world. The point to be made is that material be included or excluded on the basis of a genuine consideration of its value in meeting students' needs, and not merely justified in these terms after it has been selected on another basis.

Concern with meeting the need to be physically healthy, then, does not imply concern with the student's ability to state all the information about human structure and function that he can possibly absorb. Instead, it implies concern with helping him to develop understanding in those areas where his choices and actions may influence his health.

The phrase *develop understanding* is used advisedly in preference to *acquire information and habits,* for although scientific studies of human and animal physiology have revealed many important facts, rules, and principles of great value to every adolescent in the maintenance of his health, a series of rules of thumb will not suffice. In the first place these rules change as scientific knowledge advances and as the material and social environment shifts, and it is very difficult to change habits learned by rote. If it seems that too much attention is being paid to conscious intellectual processes in the pages that follow, this is only because habits must be intelligently chosen and self-consciously modified. Modern life gives little justification for fixed habits, but rather puts a premium on flexible ones. Accordingly a different type of habit is here urged, namely the habit of intelligently reorganizing habits in the light of new data.

Secondly, the pressure of commercial advertising and other vested interests necessitates some insight into health rules on

the part of the individual. Though detailed knowledge of the course of the researches underlying available health information is not a necessary or even desirable component of general education, it is the opinion of this Committee that *the adolescent's health habits and training should be based on at least minimal understanding.*

This minimal understanding in relation to personal health falls into two general ranges. In some health areas the adolescent needs relatively detailed knowledge as a basis for intelligent choices and habits, but in other areas increased information has no bearing upon his choices or actions. In still others there is little knowledge safely applicable by laymen. The student must become aware of this, and of the fact that much available popularized information is actually misleading and sometimes dangerous in its incompleteness (as, for example, much of the popularized knowledge of endocrinology).

The discussion that follows outlines what the Committee believes to be minimal health knowledge. It chooses the areas of diet; exercise, posture, and rest; drugs; pathogenic organisms; allergies; endocrine function; and heredity as those in which certain knowledge essential to intelligent health conduct is to be found. Pertinent teaching methods and points of view are an integral part of any such discussion.

These topics are mainly concerned with the positive contributions of modern science to physical health. It must be recognized in advance that there are certain relatively prevalent attitudes concerning the causes of disease which sometimes thwart the application of these contributions and interfere with intelligent control—attitudes which imply, for example, that insanity, syphilis, tuberculosis are moral bogies, retributive punishment for sins, or for the breaking of taboos. The Committee takes a definite stand with respect to the perpetuation of such attitudes; we insist that every adolescent —when these problems become important for him—has the right to hear the scientist's views on them, as well as the views

of those who claim other sources of information or authority, and that he then has the right to make up his own mind without coercion or moral pressure from any one.

In practice, this means that the conscientious teacher must give his students usable information, but he must not insist that it be used. On the other hand, it also means that the teacher who wishes to avoid propaganda and who has faith in the intelligence of his students must not withhold such information because it is easier to withhold it, or because certain groups of special pleaders oppose its promulgation.

Diet

Many of the connections between diet and health have been known since the beginning of history. On the other hand, important new knowledge appears almost every year. There are known effects of diet on growth, on vitality, on disposition, on complexion, and on susceptibility to disease, and some of this knowledge is usable by adolescents. The limits of applicability by the layman of recent findings and the care he must exercise in choosing his authorities on diet will be indicated later in this chapter. Permissible variations within the range of healthfulness in diet also need to be stressed. But this is one area in which detailed information may be of direct use to the individual.

Development of Desirable Characteristics of Personality (Example in Diet)

The findings of research—on the part played by the energy content of foods in animal and human physiology, for example—are directly applicable in the maintenance of health through the intelligent choice of foods. If one's sole aim were to help the adolescent maintain his physical health, then he might well take the position, "Present the practical results and rules that follow from these researches in ways to get them used intelligently, and leave the complex background of scientific procedure to those who specialize in this field." But maximum

physical health is not the sole aim; desirable characteristics of personality must be developed concomitantly.

Selection is here made of a few important conceptions from comparatively recent research related to diet to show how this research and its usable outcomes may be presented to adolescents in ways to help them develop constructive and valuable personality characteristics and at the same time gain understandings helpful in the maintenance of health. A similar cycle of procedures, aimed at both meeting the need for attainment and maintenance of health and aiding the development of the desirable characteristics of personality, may be planned in several other fields in which scientific information has been found to be relevant.

Young adolescents may be led, for example, to make their own hypotheses as to what will cause animals to be underweight, to devise experiments to test these hypotheses, to account for their results, to devise further refinements in control and variation, and finally to define the kinds of food that are rich and those that are poor in weight-building content. The wise teacher knows that many things are happening to these students concomitantly. Their experience may be expected to provide practice in reflective thinking; some realization of the (rather strict) limitations of the scientific method; a certain amount of consciousness concerning one's choice of authorities; a field in which appreciations of several kinds may be keenly developed; a hobby or other personal interest in the raising of small animals, the building of an animal calorimeter, or the preparation of a paper on food fads; an opportunity to develop social sensitivity in connection with learning the reasons why deficiency diseases are still so widespread in the richest country in the world; understandings on the basis of which important modifications in the food purchases of their families may be made; and so on.

It is thus conceivable that many if not all the desirable characteristics of personality described in Chapter II may be developed in connection with this subject, though it is likely

that different young people will be more concerned with one characteristic than with another. Further, it should be clear that in speaking here of the development of this or that characteristic of personality it is intended merely to point out that the teacher will often find it advantageous to bring out or intensify activity and attitude along one line at one time and along another line at another time.

In the example that follows, practice in reflective thinking and the use of the scientific method are the points principally in mind. This particular field—research on the part which the energy content of foods plays in animal and human physiology—may be used to help the student develop some understanding of energy and measurement, some notion of the use of controlled experiments and of the variation of single factors, and the like, at the same time that he is learning the rules of calory diet and the limitations of those rules. Though all of these conceptions have applicability far wider than the field of research now under discussion, they are best acquired in the course of experiences as simple as those described below.

All of these activities are conceived to be appropriate for younger adolescents primarily, and it is important to notice that every step in the reasoning is one that young adolescents can make for themselves.

Since combustible substances have been the main sources of heat and of mechanical energy, and since mammals produce both heat and mechanical energy, it was natural to suppose they must also be using combustible substances. The facts of eating and breathing supported this view. It is possible to burn weighed quantities of various foods in a calorimeter and measure the amounts of heat that they produce. It is also possible to feed these foods to animals and to determine how much heat the animal produces when it is storing none of this food in its body. Thus it is possible not only to find out which kinds of food have high energy and high heating values but also to find out how scientific methodology, applied to research in diet, has provided justification for the assumption of the physiologists that chemical

processes (in particular, the law of the constancy of heats of reactions) take place inside living organisms just as they do outside and can be described by the same laws and principles.[1]

A genetically homogenous litter of rats may be divided into two groups, one to be fed a normal diet (as control) and the other to be fed a diet poorer in calories, but otherwise as far as possible the same as the control diet. The weight-time curves for the two groups may be drawn on the same graph. If the difference is not permitted to become too great, the starved group may later be restored to almost normal weight. Here the single factor controlling growth and fat storage is the calory intake. Thus the notion of controlled experimentation is being used to illustrate the two aspects of the calorific value of foods—that they supply the necessary energy for the doing of physical work and the maintenance of body temperature, and that they may be stored for future use as fat and as glycogen.

But the genetic homogeneity of the litter does not of course guarantee that each rat will weigh the same at birth. The fact of variability in biological experiments has always to be taken into account. This may be done in this case by changing the membership of the two groups until the total—and therefore the average—weight of each sub-group is the same. This, in the small, is an example of statistical distribution that may well be made the starting point for the introduction of the general notion of distribution of continuous properties that pervades all biology, psychology, economics, and sociology.[2] Collateral reading and discussion of similar researches on other components of the human dietary will make clear the power of this program of variation and control. For example, a similar cycle of experiments with young rats on the effects of the vitamins is possible.

[1] The relevance of this discussion to the adolescent's world picture is clear. The connections between the teaching methods and content proposed under other captions and the developing world picture of the adolescent are too manifold for explicit mention, but they will be apparent to the teacher who recognizes the wholeness of personality.

[2] The reader will repeatedly come across examples of this property of groups in this chapter. Facility in using this concept is expected to be useful to students in activities as varied as thinking about their own weight (or intelligence or height), understanding the meaning of the word *race,* thinking about the "standard of American living," and buying life insurance. The facts of distribution and of central tendency (when this exists) will frequently be referred to in this and the succeeding chapters.

On the other hand, the history of research on diet, though sufficiently recent to be called contemporary, provides also an example of the limitations of reflective thinking. In giving these examples we have principally in mind the aim of helping adolescents realize the scope and limitations of the scientific method, and the necessity of being willing to act on the basis of tentative conclusions.

The results of the first experiments on the rôle of the energy content of foods were so striking, and the effects on humans who dieted according to calory rations so definite, that many physiologists felt that research from then on would be fairly simple and straightforward. One of the leaders in this field (Lusk) went so far as to lay down a general rule for human eating, "Take care of the calories, and the rest will take care of itself." Discoveries in connection with some of the deficiency diseases soon showed that this formulation was hardly sufficient.

Then the pendulum of emphasis swung so far in another direction that leading authorities in the field (McCollum, for example) wrote books for dieticians and laymen in which energy content receives almost incidental treatment, and the major rules laid down are concerned with vitamins, minerals, roughage, and acid-alkali balance. It is still clear, however, that the calory value of foods has a certain relevance in cases of overweight and underweight and that calory consumption must be varied according to the amount of physical work each person does. Thus, some of the value of these researches on foods has remained and the use of rules that cover only a part of the truth appears to be justified.

Similarly, the striking results of the first experiments with animals on vitamin-poor diets, and the speed with which it proved possible to isolate in high concentration the effective substances, provided an example of the power of the method of variation and control that caught the layman's eyes and led him to expect great and final discoveries. The corresponding conditions and cures were quickly established with human

subjects, and it seemed that several diseases could be immediately wiped out. Scurvy, beriberi, rickets, and pellagra were found to be directly affected by the presence of certain substances, the vitamins, in small quantities in the diet.

Here, as elsewhere, irresponsible commercial interests have seized upon the layman's ignorance to impose this or that vitamin concentrate upon him. The effects of overfeeding with vitamins are only just beginning to be investigated; some of these concentrates may be harmful; many of them are inert. The fact that a small amount of each of seven or eight substances is needed by every person for growth and for health does not necessarily lead to the conclusion that ten times as much of these substances is ten times as good for him. In fact, it seems more than likely that the vitamins that have to do with calcium metabolism, though they may be depended on to aid in the production of healthy bones when fed in small quantities, may well produce disastrous results (for example, sclerosis) when fed in larger quantities. What intake is permissible and what dangerous is at present not certain, and it is just for that reason that error must be made on the side of recommending too small rather than too large doses.

In this case as with the calory case above, more has been claimed for earlier experiments than later experimentation has shown to be justifiable; nevertheless, positive contributions to useful knowledge have been made, and it is in this sense that a certain amount of willingness to act on the basis of tentative judgment has been justified. Many other major developments in the field of biology could be used to illustrate this same point. However, no more than two or three need to be developed in full for the main points to be clear to students.

When general rules for health are being discussed, it is important for students to know which of these are based at least partly on reliable research, which are largely the result of the unofficial approved practice of the race, and which are largely folklore. It is not that folklore is necessarily to be discredited, for it represents the race's attempts to solve problems, to

simplify situations, to codify successful practice. But many of the rules of unofficial lay practice have not been developed or tested recently enough for their validity to rank with that of scientifically determined rules. More efficient, more reliable, more accurately statable rules are now available, and the scientific method provides a procedure for developing such rules.

What is important is that estimates of relative reliability should be made whenever one is confronted with suggestions coming from such different realms of experience as the three mentioned above. Under proper guidance students soon come to realize that there are certain rather definite scientific methods for investigating the effect of dozens of factors conceivably influencing their health. They will recognize at the same time that it is impossible for them actually to go through the experiments to test each of the myriad hypotheses to be proposed. Thus it will become clear that most knowledge of this kind is taken on some one else's word, and that such knowledge is worse than useless unless care is taken to evaluate the reliability of the authorities from whom it is obtained. A large part of reflective thinking consists in the efficient selection and utilization of second-, third-, and *n*th-hand information, and in the estimation of its reliability.

The development of this technique may well be started in connection with relatively simple rules about health. In estimating the reliability of the conclusions of the scientists and of others, the adolescent will be taking an important step toward his own adulthood. He will find that it is possible to criticize, and sometimes to improve on, suggestions given him by experts. He will also find it possible to accept expert opinion on the basis of reasoned judgment. The extent to which he can do this is an important measure of the extent to which he is developing the ability to direct his own activities; thus in practising reflective thinking, he is developing self-direction.

We have tried in this section to give some examples of pos-

sible teaching methods that combine the usual "giving" of information with opportunities for the development of desirable characteristics of personality. The teacher who approves this twofold aim will see that it can also be effected, and in many ways, in connection with the topics that follow.

Exercise, Posture, and Rest

Though the adolescent needs rather detailed knowledge of how much and what kind of exercise is good for him—in terms of his growth, his self-confidence, his bodily functions, and his social life—detailed knowledge about the physiology and anatomy of muscles, nerves, and bones is in no sense necessary for this purpose. So far as his own physical health is concerned, he needs hardly more than a mere awareness of the existence of various kinds of tissue in his body, and of the simplest chemical conditions for their development.[3] (The realization that some persons need much more exercise than others of the same age is also valuable.)

Similarly in regard to posture. It seems plausible that some knowledge about the complex interrelationships which exist between skeleton, viscera, muscles, and nerves may contribute to the student's attaining and maintaining a satisfactory posture, but it is hoped that teachers will consider carefully just what part of this knowledge is actually helpful and will discard all material that cannot be used by the student, no matter how accurately it may summarize the state of the science at the moment.

Most adolescents do need to be brought to a realization of the hygienically permissible range of variation in posture so that they may set realizable standards for themselves. They

[3] There may be other needs of some adolescents which can be partly met by more knowledge of human anatomy than is here recommended. One indication of such a need will be made under the section of this chapter, "Need for Esthetic Satisfactions" and another under, "Need for a Satisfactory World Picture—Evolution." Or a student who plans to become a physician might require more detailed study in this area. But such aims are not under consideration here, nor are they usually stated as the reasons for including detailed anatomical information in courses for adolescents.

need to be helped to an appreciation of the good and bad points in their own postures, and to be shown how to develop habits for correction and maintenance of good posture.

There should, of course, be included a discussion of sleep, its importance for both growing and full-grown individuals, and some analysis of the variation in amounts of sleep hygienically desirable for different individuals.

The teacher who is interested in the actual determination of the degree to which his teaching is affecting (or helping to maintain) posture and exercise habits will use the records of the physical-health department, as well as in some cases student-kept records and actual posture pictures and motion pictures of students in class, walking, and on the athletic field where these are possible. For those schools where a camera club can be formed (especially a motion-picture camera club), an opportunity is thus provided for its members to supply valuable information for the rest of the school. Such an activity may conceivably be arranged to contribute significantly to all of the phases of self-assurance.

Drugs

Though there is of course an immense mass of available information concerning the effects of drugs on the human system, most of this knowledge is usable only by scientists and physicians; adolescents, therefore, should not be burdened with it. The science teacher's most important rôle in this connection is to develop a well-fortified determination to use no drugs at all on the recommendation of advertisements, friends, or any one but a doctor.

Such an attitude cannot be fostered by mere abstract recommendation. Some teachers will want to use a few well-chosen examples of misleading or false advertising, of serious mistakes made by friends, of the disastrous results of following the advice of faith healers or other self-styled authorities, together with some of the published opinions of reputable physicians. Others will want to have students come to their own

conclusions in this field after an extensive examination of all sides of the case. But it will be found impossible to examine even a fraction of the evidence in *all* cases; so some attitudes must be built up largely on the strength of the teacher's and others' authority.

The complexion difficulties [4] that trouble so many adolescents are a special case in point. It need hardly be added that here as elsewhere the use of advertised ointments and drugs, especially on the advice of one who has been helped by them, is not to be recommended. Some of the students will have used the usual commercial products, and some will have conscientiously followed the advice of the teacher. The checking of the different results could be expected to initiate two important processes in students: first, a growing appreciation of the reliability of disinterested scientific thought as against commercialized recommendation; and second, the habit of relying upon objective check, rather than poorly sampled opinion, when judging the relative effectiveness of several proposed solutions of a problem.

Two widely consumed drugs—tobacco and alcohol—require some discussion, even though scientists report the widest possible range of opinion about their effects. Though the Committee would not want to be understood as approving indiscriminate and continuous smoking and drinking by adolescents on the ground that there is no scientific evidence contra-indicating these practices, it seems to us that the effects of tobacco and alcohol, consumed occasionally and moderately, are not of sufficiently definite or vicious permanent physiological effect to warrant any important scientific state-

[4] The treatment of acne is placed in this section on drugs only arbitrarily; it might be handled under diet, exercise, or some other heading. The sensitive teacher will not wait for questions from his students before giving what information is available on this subject. The routine control of diet, with the removal of the most commonly offending elements; proper sleep, exercise, cleanliness of skin; and the added assurance that most cases of simple acne are curable and not "just inevitable results of growing up" will go far. For the group which is not improved by such treatment, the services of a reliable dermatologist are indicated.

ment about them. There seems to be no scientific evidence available to show that an occasional drink, or an occasional cigarette, has any physiological effects beyond those immediately observable. The social pressure that some adolescents may find themselves under to drink to excess can hardly be combatted by explanations of the disturbances of digestion that may accompany such drinking, or by the citation of statistics showing that the drinking group is on the whole duller than the non-drinking group. That excessive drinking is often a sign of deep conflicts is true, but it will do the adolescent little good to tell him so. On the contrary, it may do him harm. The teacher will take such a sign as a suggestion to investigate further, if possible with the help of a guidance worker or a school psychiatrist.

It is often urged that alcohol is "habit-forming" and that therefore even occasional drinking should be discouraged. Those who hold this point of view have never accounted for the fact that drinking is generally not habit-forming, that most moderate drinkers remain moderate, and that only a few become heavy drinkers. Clearly, the habit-forming properties of alcohol depend on the drinker as well as on the drink. It is the conclusion of many psychiatrists that the causes of heavy drinking are often deeply psychological, and that exhortation and threats are alike ineffective in keeping persons with certain kinds of psychological problems from drinking to excess.

There are, of course, definite and demonstrable increases in reaction times and decreases in abilities to solve certain kinds of problems invariably associated with the ingestion of alcoholic drinks. Since there are wide individual differences in these reactions, and in the individual's reaction from time to time, every adolescent should be helped to a genuine realization that it is stupid to drink shortly before doing sustained intellectual work and criminal to drink shortly before driving an automobile.

A subject as controversial as this may provide an excellent opportunity for the evaluation of students' ability to use

authorities, as well as to test their ability to apply principles (such as that of controlled experiments), to distinguish assumptions from facts, and to recognize the fact of variability (in susceptibility to and tolerance for drugs).

Pathogenic Organisms

Though scientists working in the fields of bacteriology and protozoölogy have accumulated a very large number of facts and developed some few laws, only a tiny fraction of this material is relevant to the individual interested in maintaining his personal health. Detailed knowledge about how to prevent different kinds of infections is necessary, of course, and to some large degree will vary with the diseases prevalent in the locality. Certain diseases are so widely spread that a fairly detailed knowledge of their etiology and prevention is necessary for all adolescents.

It is strongly recommended that the teacher engaged in curriculum design consider carefully which diseases and which infections are common in his neighborhood, which are dangerous even though not common, and that he show his students how they may aid in controlling them.

For *older* adolescents, information concerning venereal prophylaxis, the recognition of infection, and reliable procedure in case of infection, constitutes some of the most important health education that the school can give. Few people realize that in this country alone there are estimated to be 500,000 new cases of syphilis a year (more than twice the number of scarlet-fever cases, eleven times the incidence of diphtheria), and that this disease could be practically wiped out by the application of existing knowledge. The American Medical Association has named the conquest of syphilis as the next great objective in public health and calls for the combined efforts of physicians, public health officials, *educators,* and the public to abolish it.

The venereal diseases represent no challenge at all to the sciences, which have at hand a particularly complete arsenal

of weapons for their control and abolition. They can be controlled when each individual has developed certain understandings and has acquired definite habits in the light of these understandings.

It is important also to disabuse the adolescent's mind concerning the ease of infection from these diseases. The myriad superstitions concerning the degree of likelihood that syphilis may be contracted from toilets, by kissing, even by touching silverware, bear witness to the ignorance and fear which surround this disease and its etiology. In addition to its adverse effects on sex attitudes, ignorant fear is ineffective in controlling disease. Accurate and complete information is available and should be transmitted to adolescents when they want it.

Some teachers will also be interested in showing the actual effect of the operation of prophylactic stations and clinics on the venereal disease rate and on public morality in Sweden, Denmark, and Germany.

Evaluation in this field (venereal disease) will depend on the school's facilities for diagnosis (medical inspection, Kahn test, Wassermann test) in so far as individual health is concerned.

Allergies

Information on the subject of sensitivities (hypersensitivities, allergic responses) has been increasing rapidly during the last few years, and the adolescent may profitably be aware of the existence of this branch of science. He should know that some people are sensitive to only one or two substances and some to a great many,[5] and he should probably know the substances which are most commonly productive of allergic symptoms. He should surely know that the only generally effective form of hygiene consists in the avoidance of the substance toward which he is allergic, and that curative measures should be undertaken only under the direction of a responsible allergist. The delicate and complicated question of when an

[5] The response of some people to ragweed pollen, to other dusts, to certain foods, etc., presents the variation of human beings in one of its most striking forms.

asthma is an allergic response, when it is a psychoneurotic one, and when it is both had probably best not be introduced except to provide an example of the inextricability of physiological and psychological behavior.

Endocrine Function

The body of knowledge concerning endocrine function in growing animals and human beings is large and rapidly increasing. In fact, the rate of increase is such that only the specialist can hazard therapeutic applications; any information the layman may acquire is certain to be fragmentary, distorted, and inadequate. Much of the knowledge about endocrine function will eventually be seen to fall into patterns and be describable by relatively simple laws of use to adolescents. However, only a small fraction of this information is at present in a usable form. Here, even more than in most fields, a little knowledge is a dangerous thing.

Closely related to the subject of the endocrines as factors in physical health is the question of the effect of the endocrine secretions and the endocrine balance on the adolescent's growth, on the development of primary and secondary sexual characteristics, and on emotions and emotional balance. The information about these relationships between the endocrines and physical development useful to the adolescent at puberty is probably of the "awareness" kind rather than of the "detailed knowledge" kind. A short discussion of the action of the thymus and of the pituitary-thyroid-gonadal complex may prepare the pre-pubescent in some slight measure for the changes that are to take place in his body.

As for the use of endocrine extracts, the general considerations in relation to drugs apply. The older adolescent who is likely to be tempted in this respect must come to realize that the advice of a physician is an absolute prerequisite, and that self-medication at best will mean the taking of inert preparations and at worst may result in serious damage to his health and development. Examples from the public press may be used

to emphasize the frequency of irresponsible and even dangerous claims on the part of advertisers ordinarily considered reliable and "ethical."

Heredity

A small amount of the information accumulated in the field of human heredity has direct applicability to human health. The mode of inheritance of a few diseases and defects (such as diabetes, feeble-mindedness, and left-handedness) is partly understood and should be of value to adolescents. Most of what the science teacher has to say is of a negative sort. Criminality, insanity, tuberculosis, "temperament," length of life are all surely influenced by hereditary factors, but the human geneticist cannot yet say *how* they are inherited. Information of this sort is of less relevance for physical health than it is for allaying anxieties. This topic can probably be developed more intelligibly in connection with the general subject of inheritance, which is taken to be more appropriately classifiable under the "Need for a Satisfying World Picture and a Workable Philosophy of Life."

The reader who has assimilated and agreed with the point of view of the preceding chapters will hardly need to be reminded that each of the foregoing topics is best taught when the teacher has clearly in mind the objectives he has settled upon and when his choice of material and of methods has been consciously controlled at every possible point by a desire to meet constructively the needs of the adolescents before him. Each of the topics mentioned, it should be repeated, provides an easy occasion for the practice of reflective thinking on the part of every member of a class, for practice in acting on the basis of tentative judgments in putting what has been learned into practice in his own life, and for self-direction in the most varied aspects of his school life. There is the possibility of developing personal interests in connection with all these topics, and surely the well-equipped teacher will know how

to help students acquire esthetic appreciations in connection with many of them. Attitudes of coöperation and of social sensitivity may be built in connection with many of the understandings referred to in this chapter.

Typical Generalizations

Though the following list of generalizations—an understanding of which may help the adolescent attain and maintain his personal health—is not exhaustive, it has been designed to indicate most of those that the teacher of science will be concerned with in helping his students to meet this need. There has in the past been much uncritical teaching of taxonomic biology, invertebrate zoölogy, and descriptive botany. On the other hand, no items in the sciences can be definitely labeled universally undesirable. But before a teacher decides that an item is desirable, he should ask himself, "Desirable for what purpose?" If this question can be honestly answered in terms of a definite need of one or more of his students, then the item should be included in that teacher's curriculum. Otherwise it must be excluded.

It is for similar reasons that neurology is not included here in the list of sciences containing valuable information for the youth of the country. The science of neurology will ultimately supply invaluable knowledge about the way the mind works, and about what human behavior is, but the generalizations in its accumulations to date are liable to more misuse than proper use at the hands of laymen.

It will be noticed that there is considerable variation in the concreteness and usability of these generalizations, but the attempt has been made to put each into a form that would suggest both to the teacher and to the student how the latter may go about controlling his behavior so as best to conserve his personal health. Many of them are of such a broadly interpretative nature that they are equally relevant to the development of a world picture and to the maintenance of self-assurance; they are listed here because of their relevance to

the development of desirable characteristics of personality as well as because of their bearing on personal health.

1. The interactions between physical health and the states often called mental and emotional are so intimate that a clear separation between them cannot be made.
2. Diet has important effects on growth, physical energy, disposition, complexion, and disease.
   a. Calories, vitamins, allergies, proteins, fats, carbohydrates, roughage, minerals, water exist as important factors in diet. (Awareness rather than detailed knowledge is needed here.)
   b. In view of the wide variety of available foods, of the bombardment by food fads and advertising, of the dicta of ill-informed religious groups, and of the restrictions of different budgetary levels, each person needs detailed knowledge of his own dietary needs, what to choose, when to eat, and the effects of various choices.
3. The method of varying single factors (as in the diet of animals) which makes it possible to discover the effects of each factor is one of the most powerful tools of the scientific method.
4. Health programs based upon science findings have demonstrably improved average health, even though in most cases serious omissions have later been found in the program. (This emphasizes the desirability of scientific knowledge, even when incomplete, as it generally is, as a basis for action.)
5. Scientific thinking and attitudes have important applications for the individual in the field of health.
6. The technique of evaluating authorities is an indispensable part of the layman's equipment in selecting and using the more reliable from the mass of information and misinformation with which he is generally presented.
7. Mental and physical health is more dependent on intelligently chosen habits and attitudes than on therapy.
8. Certain attitudes concerning the causes of diseases (for example, those which conceive of insanity, syphilis, or tuberculosis as punishment for sins or for breaking of taboos) are still interfering with their intelligent control.

9. Scientists assume, in investigating any piece of human behavior, structure, or function that the laws of physics and chemistry hold within organisms as they do outside them, and that whatever an organism does, is, or becomes, is the result of genetic and environmental factors, of their interaction, and of nothing else.
10. Exercise, good posture, and rest are important for growth, for self-confidence, for bodily function, and for social life.
    a. Muscles, nerves, bones, fat, and the simplest chemical conditions for their development are involved in problems of exercise, and in any efficient physical activity.
    b. Posture depends on complex interrelationships between viscera, skeleton, muscles, and nerves. (Awareness rather than detailed knowledge is needed here.)
    c. The kind and amount of exercise which is desirable varies with the individual.
    d. A wide variation in posture is hygienically permissible.
11. Drugs are a valid part of medical treatment of disease, but are dangerous in the hands of laymen, especially in the self-medication recommended by advertisements or friends.
12. Many patent medicines contain drugs which dangerously upset the body metabolism or are habit-forming.
13. Although alcohol in moderate quantities has no permanent ill effects (as far as is known at present), even in small quantities it temporarily retards reaction time.
14. Although tolerance for tobacco varies widely with the individual, no responsibly conducted research indicates that small amounts of tobacco have adverse effect on the "wind" of all athletes, the growth of most sixteen-year-olds, the future fertility of girls, or any other physiological function.
15. Preventive medicine has been and is more effective than therapeutic medicine.
16. Most diseases are more easily treated if diagnosis is made early and competently.
17. Communicable diseases are due to specific micro-organisms or viruses.
18. The control of infection depends on knowledge of how the disease is spread and of available preventive and therapeutic measures.

19. The most recent discoveries in medicine and human biology, particularly those concerning endocrines, allergies, integrative nerve action, vitamins, are not applicable by the layman with the same degree of assurance as are older, better established findings (such as those previously indicated).
20. Diagnosis, medication, advice concerning the physical side of major problems (dietary changes, marriage, having a child) are the functions of licensed physicians.
21. Consumer advertising of medicines, foods, cigarettes, especially when it describes scientific findings, is only to be accepted when it is checked by several disinterested experts (Consumers' Research, Consumers Union, American Medical Association, etc.).
22. A knowledge of which important characters are inherited and of the laws of their transmission, has implications for one's behavior, both somatic and reproductive.

THE NEED FOR SELF-ASSURANCE

It is highly important to consider how the science curriculum may best contribute to the attainment of a certain amount of self-assurance—another essential condition of effective and satisfactory personal living. It seems clear that there is no problem or series of units around which to center teaching procedure for the meeting of this need, which thus differs in some categorical way from the need for the attainment and maintenance of physical health.

The first problem to be solved in meeting the need lies in the initial determination of just "how much" self-assurance each student has. The variety of "symptoms" that may indicate a relative lack in this respect is at first sight staggering. Many samples of behavior, entirely normal in one context, in other contexts may signify lacks almost pathological. Nevertheless, after a certain amount of rapport has been established between teacher and student, the teacher may be able to answer such questions as these: Does the student always skip over situations in which his own personal development (physical,

social, or mental) might become the topic of discussion or investigation? Does he always omit mention of physical development, of secondary sexual characteristics, of height or weight or complexion variations? Does the student spend a good deal of time showing off, defying discipline, knowing it all, boasting? Does he habitually bluff or lie? Positive answers to these questions may mean little, but when behavior of this type is coupled with serious deficiencies in the same person's social life, then it may well be suspected that self-assurance is to some important degree lacking.

Adolescents who put a large part of their energy into the pursuit of the so-called abstract subjects are frequently manifesting a symptom of unhappiness and conflict in other aspects of their living. Does the student show an intense interest only in the "purely intellectual" parts of whatever is being taught? Does he choose astronomy, and Latin, and geometry, and the other "impersonal" subjects in preference to physical education, art, music, literature? An affirmative answer to these questions need not necessarily mean that a student lacks self-assurance, but if in addition he makes no friends (or is out of touch and out of sympathy with his parents, or is ashamed of his own body, or has tried to be an athlete and failed, or never goes to parties and dances, or lives most of his life in his own little world), then the teacher is entitled to suppose that his "intellectual-impersonal" preoccupations are largely compensatory for a serious lack in self-assurance.[6]

It does not follow, of course, that the reticent student should be compelled to talk of the things which he avoids, or that the braggart should be "put in his place," or that subject-matter which makes direct call upon the emotions should be forced upon the adolescent who consistently avoids and rejects it.

[6] It is to be carefully noted that no plea is here being made for extroversion as against introversion. Society can well use more introverts, abstract thinkers, people who can bear privacy and who do not need constant external stimulation and competition to keep them active. But to be effective the abstract thinker must be motivated at least in part by his enjoyment in achieving, and not mainly by a disorganizing fear of social life, by a general tendency to escape from social obligations.

When these symptoms begin to disappear, the teacher will know that a student is beginning to develop some modicum of self-assurance, but the way does not lie through exhortation or compulsion. And although subject-matter taken directly from the natural sciences may help a vast number of students build self-assurance, many cases will arise in which this attack will not be found sufficient. For these, deeper analysis of the sources of conflict is necessary, and the science teacher generally needs the expert assistance of a guidance worker.

But even when a guidance worker is not available, much can be done by the science teacher who regularly interprets the worries, troubles, problems, difficulties, and minor neuroses of his students as significant symptoms, as warnings that something is going on, and who does not become worried, intolerant, or irritated himself in the face of these facts.

Such a teacher will hardly need to be told that objectivity in tone when approaching problems and questions which are emotionally charged for the student is desirable only when it does not interfere with or mask genuine friendliness. A considerable part of the reassurance the student obtains from the teacher resides in the fact that he knows that the older person is interested in his problems and his preoccupation with them.

In addition, the Committee suggests several ways in which the teacher can proceed rather directly toward the problem of meeting the normal need of adolescents for self-assurance. He may give his students some opportunity to assume increasingly mature responsibilities or to attack and solve some problems that are important enough to give them a sense of achievement, but he will be gentle and sensitive to the occasional need of many students for opportunity to escape from problems that are at the time too difficult. And he may give his students many opportunities to realize the normality of variability, and the purely statistical, only remotely normative importance of averages as determiners of what is normal in physical-mental-emotional development. Though these ways of helping adolescents gain in self-assurance do not all suggest definite

subject-matter, the teacher who has them in mind will know how to change both his course and his treatment of individual students.

Opportunity to Assume Increasingly Mature Responsibilities

Adolescents need opportunity to assume more and more mature responsibilities, and nothing satisfies their need for self-assurance so constructively or to the same degree. Clearly, recognition of this fact by teachers will make considerable differences in their teaching, but clearly, too, no single unit of subject-matter is being recommended. The opportunity must be continually available.

For millions of older adolescents in this country, the most reassuring opportunity to assume universally recognized adult responsibility is lacking. There are not enough jobs. It cannot be too strongly urged that, wherever possible, honest consideration of this problem be given the classroom time it merits, and that it be faced squarely, with reflective thinking, and a willingness to act on the basis of tentative judgment. But though the discussion of this problem in the schools would be a step forward, it will not of itself constitute adult responsibility.

If getting a job and earning money were replaced in the minds of American people as the most important sign of maturity and adult status by such things as attendance at a university, marriage, having children, or membership in adult groups, it might be easier for the older adolescent to gain self-assurance. But the Committee has not given serious consideration to the problems involved in bringing about such a shift in thinking and might not be ready to advocate the changes in social-economic forms necessary to bring about such a state of affairs. Consequently the Committee must take the position that young people should be aided to get jobs.

The teacher who can help young people solve this problem of getting jobs will be helping them to gain self-assurance. If there are not enough jobs for young people who are seeking

them, and if they cannot discover opportunity to assume adult responsibility in other ways, they will naturally turn to consideration of ways to make more jobs. The students may conclude that some form of sharing the work is necessary, and that rises in wages should follow. By coöperating with other job-hunters to put through such a program they may gain a measure of self-assurance through assuming mature responsibility in the solution of a genuinely adult problem. In all of this, the teacher has the obligation to aid and advise his students, so as to help them think through the problem intelligently, use the most objective sources of information, evaluate authorities carefully, consider the social consequences of their acts, and act on the basis of their best tentative judgment.

In addition to the achievement of adult status through participation in economic activities, adolescents, both older and younger, may gain in self-assurance through exercising increasingly mature responsibilities within the school and in relation to their own education. They may be given opportunity to criticize and improve the teaching of courses, the management of laboratories, the administration of the school—to say what things they find interesting, what difficult, what pointless, and what boring in their school lives—as well as ample opportunity to plan, direct, and control their own activities. Here it can hardly be too much emphasized that the assumption of such responsibilities by adolescents must be gradual, lest too sudden an increase of freedom prove a boomerang—actually encouraging regression in the direction of immaturity rather than fostering an increasing maturity.

In so far as science activities are concerned, a study of the energy content of foods (such as that outlined in an earlier part of this chapter) may well include a study of meals served in school cafeterias or, in some cases, of the (anonymously presented) dietaries of the students themselves. Such a study often results in a concrete list of suggestions for changes in cafeteria and home menus. If, combining tact with knowl-

edge, the adolescent can improve his home dietary and, acting collectively, can do the same in his school lunchroom, he is assuming mature responsibilities and certainly gaining in self-assurance thereby.

Similar projects are desirable and feasible in many other contexts. Younger adolescents are able to assume responsibilities in connection with a well-organized comparative testing program of such school commodities as ink, paper, chalk. Older adolescents have made responsible suggestions for the improvement of ventilation systems (control of humidity, drafts, temperature) as the result of systematic study. The Committee is aware that such work takes a great deal of time and makes it impossible to follow a prescribed syllabus; however, it sees no other way to meet the developing adolescent's need for self-assurance so constructively; it therefore condemns the detailed syllabus rather than the fumbling student who is trying to be effective, to assert himself, to grow up.

Many teachers will recognize in themselves a certain reluctance to help adolescents grow up through activities of this sort. "After all, they are still children, not adults," they will say, fearing that these projects may threaten their authority. But as a matter of fact teachers who have tried such projects have not suffered any diminution in esteem, but seem, on the contrary, more highly regarded by young people eager to grow up. Many teachers, too, recognize that they have parental, protective feelings toward their charges and do not really want them to grow up, to do the things that adults do, to become emotionally and intellectually independent. But this conflict is not insoluble. Parents and teachers *in loco parentis* also grow up, and the coming to manhood and womanhood of their children is hardly an event they ought to oppose.

Opportunity to Gain a Sense of Achievement

Many students can achieve some measure of self-assurance by performing tasks which are important to them, which they

can complete largely by themselves, and which they can evaluate in terms of their own progress—whether or not they lead in the direction of recognized adult status.

The need for a sense of accomplishment is nearly universal. It may be satisfied in an extraordinarily wide variety of ways, and trivial or routine activities have sometimes been justified by teachers on this basis. Conceivably, some students may meet this need by completing a prescribed task ("Do all the even-numbered problems"), but this will hold only for those very few to whom the task represents something new, something rather urgently desired, or something useful. It also sometimes happens that a young person seems to derive a sense of achievement from repeating some learned operation over and over again: it may be a poem he has memorized, a piece of piano music, a laboratory "experiment," an arithmetic paradigm, even a standard verb conjugation. Here is something he really knows, really can do, and sometimes he needs the self-assurance that its repetition can give. But generally speaking, in order to help satisfy this need a project must be challenging and self-chosen, and the teacher must remain in the background.

The problem of the teacher and curriculum-builder is to meet the need for a sense of achievement constructively, and the Committee has taken the position that a need is met constructively when it is satisfied in ways to develop desirable characteristics of personality like those listed in Chapter II. Among these, creativeness and esthetic appreciations are most likely to be developed in connection with the need for a sense of accomplishment, and personal interests seem to be the most direct form of activity around which to center their development.

Opportunity to Escape from Problems That Are for the Moment Too Difficult

Care must be taken lest emphasis on the abiding needs of the adolescent, his pressing problems, and his developing personality lead to the assumption that he can solve all his prob-

lems by direct attack and achievement. He may be so hard pressed to achieve that his self-assurance is threatened and can be reëstablished only through some let-up in the attack. Sometimes he will want not so much an answer to his questions as a chance to postpone them for a little while. His troubles may be so immediate that he cannot attack them this year and wants to study astronomy instead. This need can also be respected; such activity may be called escape, but with no derogatory intent. He is choosing for the sake of his emotional health.

Similarly, the persistence with which the value of useful knowledge and of desirable characteristics of personality has been urged should not call the legitimacy of simple relaxation into question. Surely the movie, the radio, and the pulp magazine satisfy needs (though they cannot generally be said to do so constructively), or they would not be so widely consumed. Action cannot always be based on rationality alone, and fatigue, boredom, and drabness are also real factors influencing conduct—the conduct of adolescents perhaps especially.

If the teacher can find out whether or not all the subjects the student is choosing are remote and intellectualized, and whether he seems badly or well adjusted socially, he can estimate the purpose for which the subjects are being chosen and decide whether the student requires the services of a guidance worker, or whether he just needs to be left alone for a while. In either case, the goal is to help him toward greater self-assurance.

Opportunity to Gain a Sense of Proportion through a Functioning Understanding of Normal Variability

There is a phase of the problem of increasing the self-assurance of adolescents that might be indicated by stating that everybody needs a *sense of proportion*. Many students are worried by aspects of their own development which seem to them abnormal or sub-normal. For the sake of their self-assurance it is often desirable to develop understandings concerning physical development over and above those necessary for the main-

tenance of physical health. But many worry about their behavior and emotions as well as their anatomy and feel that they must hide or bluff about their mental or emotional inferiorities. Some of these are reassured by being shown that development is not uniform through time or for any of the characteristics of a given person, and that the human population presents a wide range of normal variability with respect to most of its attributes.

It would seem that students *need,* then, a functioning understanding of variability. Any subject-matter that deals with human characteristics may be used as a vehicle for the satisfaction of this need, and no one special subject-matter can be singled out as best. Uniformity of trend, central tendency, and dispersion are the basic concepts of the science of statistics, and elementary applications of statistical methods are one of the best ways to put the growing and generally "abnormal" adolescent at ease with respect to the characteristics of his own peculiar self. The converse aspect of this point of view, namely the variability of other people, develops concomitantly.

Typical Generalizations

(For a discussion of the proposed uses of these generalizations and their limitations, see page 85.)

1. Many physical and mental characteristics show a wide range of normal variation, both between individuals and in the same individual at different times.
2. Many emotional conflicts and feelings of inadequacy or shame and fear are created or enhanced by the failure to realize what behavior and what physical or physiological characteristics are normal in human beings, and in adolescent development in particular.
   a. Physical and psychological characteristics show a wide range of variation among individuals, and some variation in the same individual at different times.
   b. An individual's physiological and psychological characteristics, and his resultant behavior and problems, are seldom peculiar to him alone.

c. Feelings of shame are socially conditioned—and in our society overly and hurtfully developed with respect to many normal activities, such as ingestion, excretion, and sexual activity.

3. An individual passes through successive changes in physical growth; growth is, in general, gradual, but periods of acceleration and retardation occur.
   a. Early stages of development are characterized by rapid physical growth.
   b. The organs of the human body develop at different rates and at different periods in the life of the individual.
   c. Unusually rapid or slow growth at adolescence may cause social, emotional, and health problems for the individual.
   d. An individual's social adjustments are limited by the level of his physiological maturation.
   e. Individuals reach sexual maturity earlier than they reach economic and social maturity; this may produce important conflicts at adolescence.
   f. Endocrine secretions constitute a factor controlling the growth and affecting the behavior of individuals.
4. Every expressed character in an individual is the product of the interaction of hereditary and environmental factors.
5. An individual continuously interacts with his surroundings.
   a. An individual makes contact with his environment by means of stimuli he receives from objects within it.
      (1) Individuals differ in their degree of sensitivity to various stimuli.
   b. The response of an individual to any situation depends, in part, upon his previous experience.

THE NEED FOR A SATISFYING WORLD PICTURE AND A WORKABLE PHILOSOPHY OF LIFE

The third need of the adolescent in his personal living lies in the development of a satisfying world picture, along with a workable philosophy of life. Of course, no person's philosophy of life could possibly be workable did it not both influence and rest upon his immediate and wider social and economic relationships as well as personal living, and it is consequently

somewhat arbitrary to include this discussion under the heading of personal living alone.

The two phrases, world picture and workable philosophy of life, are used in conjunction here because they supplement each other: world picture is taken to include an attitude toward the external world, whereas philosophy of life refers to attitudes toward the self and other people. The individual needs a rational view of the world; he needs a moral code. Though he must develop both in harmony with democratic ideals, it would be presumptuous to set down *the* correct world picture or *the* correct philosophy of life. Yet the Committee is of the opinion that it is possible to set down certain components of any modern world picture and to indicate with a fair degree of explicitness which of these can be developed by teachers of science.

The term *world model* or *world picture* has been used with different meanings by different writers in education. Many of these think that the parts of the world important for the student are those which lie closest around him—importance to be judged perhaps as falling off a little faster than the inverse square of the distance. Others have tended to emphasize the importance of a knowledge and a view of the physical universe as a whole.

Though the Committee tends to agree in general with the first group, it does not accept mere physical proximity as a criterion but stresses instead those major scientific ideas that have a definite bearing upon the adolescent's development of a rational and consistent world picture. The atoms of the adolescent's hand, for example, are not necessarily a vital part of the "world" which impinges upon him; it is difficult to imagine the average adolescent in a situation in which a knowledge of the properties of the atom would make a significant difference in his actions or his meditations—affect in any important way his attitudes toward the external world or toward himself and other people.

Major Scientific Ideas of Importance in the Adolescent's World Picture and Philosophy of Life

The Committee proposes as examples:

Scientific Methods as Bases of Belief
Evolution, Organic and Inorganic
Scientific Laws, Prediction, and Control
Efficiency
Probability and Statistics
Operational Thinking

There is a group of writers on education who hold that a satisfactory world picture involves a comprehensive knowledge of the physical universe. Undoubtedly much of the enthusiasm for this position is based upon the fact that the various fields included afford excellent examples of the manner in which reflective thinking has operated. A study of such examples, it is held, leads to keen appreciations. Frequently, however, such appreciations are regarded as ends in themselves, rather than as stimuli to the development of a workable philosophy.

It must be admitted that cosmology was of first importance for general education in the seventeenth and eighteenth centuries because at that time the authority of the church in this area was being attacked and its explanations refuted by the natural scientists. In those parts of the country and among those groups of people where this conflict is still an issue, it continues to be important for teachers of science to explain some of the present views of physicists and geologists to their students, but they need not be reminded that this sort of teaching defeats its own purpose if the present positions of science are set up as final truths to be accepted in place of those promulgated on the basis of extra-scientific authority.

Faith in intelligence and in the value of reflective thinking requires that students first be given access to all available relevant data and that their decisions then be respected—as to point of view, as to outcomes in action, as to acceptance of

the merits of the various programs offered, and as to the authorities ultimately accepted in each realm of experience.

Scientific Methods as Bases of Belief

One of the fundamental questions that each adolescent or adult must ask and answer at each point in his development is, "Which authorities do I accept and which do I reject?" This would be an ambiguous question to pose out of all context, but when asked in connection with a definite field of interest, its answer requires a searching analysis of the basis of belief. Even in questions of simple fact the young child soon learns that his parents are not infallible. Later he makes some of his teachers his authorities, and still later he turns to books for the most reliable information. In problems of morals a similar development generally takes place.

As the young adolescent finds that his accepted authorities differ (first probably in simple questions of fact, later in more complex aspects), he may well feel insecure. He often turns with his pressing problems to some source whose correctness is not questioned in his narrow circle of acquaintance. It is only natural that he should then assume for a time that he has found the way to answer all questions and solve all difficulties. But sooner or later he finds that his authority does not agree with another authority on an answer that presumably ought to be ascertainable with definiteness and objectivity. It is then he begins to learn that the evaluation of the reliability of authorities (and of the range in which each is in fact an authority) constitutes an important part of his own problem, and a part which cannot be put off on some one else.

Since most laymen cannot in the nature of things acquire first-hand information on many of the questions that they are anxious to have answered, the older adolescent must be helped to understand that the evaluation of authorities is a large part of the scientific method for laymen. This is not easy, since knowledge is steadily developing, truth is only partial and never final, and authorities shift for the race as for the adoles-

cent himself. Nevertheless adolescents may be helped to face these changes, and indeed to derive strength from them by learning something of how to evaluate authorities.

When the questions involved are important and interesting enough to the adolescent, it may be possible to get him to ask several questions before he decides whom to accept as an authority. Is the authority logical? What can be found out about his bias? What is he trying to prove? What authorities does *he* accept? Has he been used successfully before? What do other authorities say about the same subject and about this authority in particular? Does authority transfer? (For example, is an authoritative physicist necessarily an authoritative economist? Necessarily not?)

Though older adolescents should develop the habit of questioning and critically evaluating the sources of their information and points of view (their teachers included), it stands to reason that this habit should not be encouraged to the point of unsettling students permanently, nor should young people accept an obligation to keep up with the most advanced opinion in, say, such a field as cosmogony.

It is in the field of the physical and biological sciences that it is easiest to evaluate authorities, and it is in this realm that the science teacher may be of real assistance to his students. Before the advent of modern astronomy and biology it was natural for theologians and clerical philosophers to assume that the authority of the church legitimately extended into these fields. But the science teacher must now help students to see that the best authority in these fields is to be found among those who are pursuing scientific study.

The reasons for calling the scientists the "best" authorities in this field are simple. In the first place they are the specialists in the field. Secondly, their theories are the ones that are found to give the most reliable predictions and the largest measure of control. In short, their methods work. Thirdly, their methods leave room for later improvement and change, since they do not assume finality or infallibility for their conclusions.

The science teacher should present the methods and the findings of the natural sciences objectively and encourage—not exhort—young people to make consistency one of the basic criteria of their beliefs.

A tolerant view toward the beliefs of others, often less fortunate than themselves in their opportunities for learning, and a tolerant view toward the beliefs of ages past are both necessary requirements in the attainment of a scientific attitude. These points can often best be made with young people by showing them how their own beliefs are undergoing development and change as they themselves grow older, acquire new knowledge, and develop new attitudes.

Organic Evolution, Modern Conceptions of Heredity, and Inorganic Evolution

For most of those who have understood it, the advance of biological science in the past century has profoundly affected their world picture, and among biological ideas that of organic evolution has had most direct impact on the lay mind.

As developed by the thinkers of the last century, this idea was made into a direct refutation of many of the dicta of revealed religion. Since the dominant religions and churches of the western world then claimed to have accurate and final knowledge concerning remote happenings in the physical world, the nineteenth-century theories of evolution were comparable to the sixteenth-century Copernican revolution in their attack upon religious authority. These theories cast serious doubts on the reliability of theological statements concerning times long past.

The contemporary adolescent is immersed in an atmosphere that has been deeply affected by this controversy and its repercussions, and this atmosphere is by no means homogeneous, varying widely from place to place and from social group to social group in any given locality. Teachers hardly need be reminded that such a topic as evolution is most important where it is moot. If the mere mention of the word

is frowned upon by some members of a local group, the teacher will surely not take that as a signal to refrain but rather as an indication of the direction and pace of his own teaching. It may be that he will have to move toward this objective very slowly indeed, but move he will. Similarly in regard to those parts of the country where the offering of any subject-matter directly related to evolution meets with suppression—these are the places where the young people must be helped especially to develop understandings on this subject. Adverse pressure merely means that more care must be taken not to offend community opinion, but it is important to emphasize that more care in presentation does not imply that this topic be omitted.

Concrete teaching suggestions applicable to such a variety of circumstances can hardly be made. In areas where evolution is a moot issue, it is certain that the program should not involve a matching of organized strengths so much as a painstaking, tolerant presentation of facts, which may at first be only remotely connected with the concept itself—faith in reflective thinking as an activity which can be fostered in adolescents implies that controversial topics must not be approached from the belligerent stance of superior people who know they are right and that their opponents are wrong. Such a program might, for example, be concerned at first only with showing some of the evidence (from comparative anatomy, comparative embryology, comparative physiology, and paleontology) concerning the genetic relatedness of forms among the lower mammals. In those areas of the country where a direct attack on this topic is impossible, an approach may be made through one of the less familiar avenues, for example, through a study of inheritance in fruit flies, peas, mice, or, later, some of the simpler characteristics of human beings (blood type, taste-blindness, direction of hair-whorl, blue-eyedness). This should be carried to the point where the question of the evolution of the higher mammals, including man, would be brought up by the students themselves.

Eventually it may be possible to point out—what might well be the starting place in other localities—that all living organisms, including man, show evidences of genetic relationship; that this evidence comes from many fields (paleontology, embryology, genetics, cytology, comparative physiology, comparative anatomy, animal breeding); that plausible, logical arguments can be found to account for the apparent diversity of living species; that experimentation on evolution is actually possible; that the science has developed to the point where the groundwork of a mathematical theory of evolution has been laid down.

Eventually also it may be possible to note the important fact that in the controversies that continue to rage over evolution, with scientists and laymen (including clerics) on both sides, the fruitful contributions have come mainly from those who brought to the controversy the methods and the knowledge of the scientist—who assumes that no outside agency or purpose is operating in the evolutionary process, and that any human behavior, structure, or function is the result of the interplay of environmental and genetic factors and of nothing else. If the question be pushed further back to ask whether the biological or physical sciences have anything to say about the "creation of the universe," the answer must be that though all observable events taking place in space and time must eventually come into the field of physical laws, the "creation of the universe" has so far not been given any physical meaning and therefore is not a subject for the scientist to discuss.[7]

As churchmen, some quite grudgingly, have relinquished their authority in this area, scientists have proceeded to strengthen, refine, and correct the general conclusions of the first evolutionists. The idea of evolution sketched above was already well formed by the beginning of the century; a tremendous development in the theory of organic evolution has taken place in the last thirty years. Though the work of R. A.

[7] For a more extended discussion of this position, see the section on operational thinking in Chapter VII, pp. 335–342.

Fisher, Sewall Wright, J. B. S. Haldane,[8] and their schools is largely couched in mathematical terms that are difficult to make clear to laymen, some of their reasoning and conclusions are already available. Many adolescents will want to know of the existence of this work even if they do not propose to spend time studying it. The work of N. I. Vavilov and his school on the evolutionary spread of the food plants, and the work of L. Hogben, F. Bernstein, and others on human mutation, variation, and inheritance can easily be summarized in non-mathematical terms and provide striking justification for the application of the scientific method to problems of extreme complexity.

As elsewhere, the effect that teaching is having on students' attitudes and world picture will depend on the way in which the subject is approached. Does the teacher want his students to realize the way scientists use evidence? The power of independent evidence converging from several fields? The value of unifying concepts that make order out of a million known but apparently disparate facts? Then it will not do to approach the topic through such questions as "What do you think of Darwin's Theory?" or "Do you believe that your soul evolved from some lower animal?" Questions must be much more specific, though they should not require too much detailed knowledge, and they should be suggestive, even provocative.

Such questions as the following serve as a point of departure in study and discussion:

Can you give an example of an animal whose evolution has been traced by a series of fossil bones that show gradual change?

Is the fact that some fish embryos look a great deal like chick embryos at an early stage a coincidence? What does it indicate?

Give five ways in which a whale and a mouse are alike. Five in which they are different.

[8] The specific mention of the names of reliable workers in these fields is doubly important here because so many works published for laymen are worse than worthless, at almost every turn reflecting faulty thinking at the service of unworthy motives.

Did Darwin say that "man descended from a monkey"?

Do scientists think that plants also went through a process of evolution?

Has any evolution taken place in any animals during historical times, or did it all take place in the remote past?

Does a man's body have any bones or muscles that do not have their corresponding parts in the body of a chimpanzee?

Do chimpanzees have any intelligence?

Why is it against the law to teach "evolution" in certain states?

Are there any scientists who oppose the general idea of evolution? To what groups do the opponents of evolution belong?

Have any fossil bones been found that have some human and some ape-like characteristics (so-called missing links)?

Are some of the races of man closer to the apes than others?

Are all the races of man of the same *species?*

Where are pure races of human beings to be found?

Who are the Nordics (Aryans)? Are there any ethnologists (scientists who study races) who claim that the Nordics are natural rulers, heroic, soldierly, and breeding more geniuses than any other race?

The habit of looking for causes, the ability to make simple scientific (deterministic, mechanistic) hypotheses, the habit of devising or imagining simple controlled experiments, the ability to distinguish assumptions from facts and to recognize the rôle that each plays in scientific thinking, all can be developed by the teacher who gives his students opportunity for their practice. Some teachers will want to emphasize also the concepts of statistics in their work on evolution and heredity. In fact, without the idea of variability it will be all but impossible to give an accurate picture of the distribution of the continuous characteristics (like intelligence, height, musical ability, nasal and cephalic indexes, athletic abilities) among the races of men.

The results of the modern study of heredity are so intimately related to emerging evolutionary theory as to require consideration in immediate connection. As in the controversies over evolution, the vehement and extended discussions concern-

ing the relative importance of "heredity" and "environment" have been advanced most definitely by the scientists on both sides, and like the scientific students of evolution, the human geneticists assume that the processes of inheritance in man are describable by laws similar to those applicable to other animals and to plants.

As the result of much experimental and theoretical work the conclusion was reached that every expressed character of an individual is the product of the interaction of hereditary and environmental factors. Since all hereditary characters require an environment in which to develop, there is no such thing as heredity separate from environment. Further analysis showed that an important part of the environment of each hereditary factor is the presence of all the other hereditary factors.

The basic mechanisms of heredity have been and continue to be deduced from the statistical results of breeding experiments on plants and animals. The deduction of the existence of the genes and of their linear arrangement in chromosomes from these experiments has been strikingly supported by cytological research; it has proved possible actually to see the chromosomes go through just such changes in the course of each cell's development as would be required to account for the facts of organic growth, reproduction, and inheritance. More recently it has even been possible to demonstrate under the microscope the actual location of the genes on the chromosomes, and this location corresponds in all cases to the location deduced from genetic experimentation.

The known laws of heredity, plus the knowledge of the occurrence of several kinds of heritable mutation, plus the known properties of statistical groups with changing characteristics, seem to be sufficient to account for all the observed variation in organic species, as well as for the resemblances. The whale is some sixty million times as heavy as the mouse, but they both nurse their young, and both have skeletons made of the same stuff with corresponding bones. The first fact may be said to be due to the mutation in the past of many of the

genes of their common ancestor which enables one to turn large quantities of food into his own substance and the other to convert only a little. The second is due to the fact that the great mass of genes has not changed at all, so that the two species have still so much in common that they are not only in the same phylum but even in the same class. It will be clear to any adolescent who understands this that no special act of creation or other supernatural cause is now needed to account for the existence of each of the half-million species of animals.

The idea of evolution has of course been extended into the inorganic field and into the range between the organic and inorganic. Though it would be premature to say that the laws of physics and chemistry apply inside living organisms exactly as they do outside, it is certain that this hypothesis has served the physiologists so well that none dreams of changing it for another. The chemistry of nutrition, growth, reproduction, and photosynthesis has been worked out in considerable detail without the discovery of any facts that would indicate a limitation upon these laws. But there are other ranges of data (structure, differentiation, convergence, complex function, "adaptation") for which the laws of physics and chemistry known at present do not yet suffice to describe adequately all the relevant facts, though the laws still apply. (It is to be noted that even in the fields of physics and chemistry there are facts of a complex nature—like atomicity, ferromagnetism, and others—that are not yet completely describable in terms of the older discovered laws, but no one proposes that new causes, entelechies, or supernatural purposes be introduced to account for them.)

Nor is there need to introduce a new kind of law or new entities to account for the phenomena of the intermediate range between living and non-living things. Below the one-celled animals and plants are the bacteria and then the filterable viruses. The estimated size of the latter indicates that they are not much larger than a large protein molecule might be. That one of them has already been isolated in crystalline form

(formerly considered to be characteristic of "dead" matter) seems to come very close indeed to bridging the gap between living and dead matter.

Many teachers will feel that the evolution of the physical universe, of the stars and the earth and the surface of the earth, is also an important part of the adolescent's world picture. Though this is an important part of the scientist's world picture, this fact alone does not make it essential in general education. The criterion to be applied in this connection, as in connection with all material that might enter into general education, is its definite effectiveness in relation to the attitudes and conduct of the student.

Nineteenth-century science accumulated a vast body of facts about the physical universe. The early effects of these discoveries upon laymen were simple, perhaps oversimple, and yet profound. The first direct measurements of stellar parallax (which enlarged the scale of the physical universe and thus made the solar system a tiny element in a much larger system) were interpreted to indicate the relative insignificance of the earth in the "scheme" of things, and it was somehow harder to believe in a creator whose main interest was man, after man had found out what a small part of a big universe he occupies. A more logical interpretation would have recognized the measurement of stellar distances as a triumph of the human mind, working according to a method, and would have conserved human values and not diminished human importance.

This method has had and will continue to have profound effects on morals, on philosophy of life, and on world picture, through its effects on man's need for a supernatural explanation of natural phenomena. Scientists following Laplace have found less and less need for the hypothesis of a controlling deity. Rather, they have found a systematic way of solving physical problems, simpler ways of describing physical facts, and more reliable ways of extending these descriptions into new fields. Thus the scientists are becoming their own guides

and their own critics. This is not to say that science is a closed area, uninfluenced by prevailing climates of opinion, ideologies, cultures, but rather that the success of the scientific method in solving problems is reducing the need for large-scale hypotheses (like that of a purposive deity) to fill in the gaps and to cement together man's view of things as a whole.

A simplified historical approach to the modern scientific world picture may be useful for young people who have received definite and erroneous ideas concerning the nature and history of the physical universe and of life on the earth. If such a young person can be aided to realize that his own world picture differs from that held by the writers of the Old Testament or the early church fathers, and that it is the result of a development of knowledge beyond that available to early religious authorities, he may more easily examine new evidence and make for himself a world picture more in consonance with the facts now known.

Scientific Laws, Prediction, and Control

It is frequently stated that "nature obeys laws," or that "nature is governed by immutable laws." These expressions are metaphorical. They are never meant to imply that the laws are in any way analogous to imposed rules, or that the laws were "there" before nature was. These forms of ellipsis are dangerous if they are taken to mean more than that the physicist looks for and finds uniformities in the natural world which he then tries to express as compactly as possible in statements which are dignified with the name of laws. It would be closer to the facts to say that each generation of physicists devises concise descriptions of the then known uniformities with whatever degree of precision is justified by the data at hand, and that succeeding generations of physicists steadily find new and more accurate formulations, which may or may not be like the older ones, but which fit both all the old data and also all the new data. The laws of physics are man-made, and man-changed, and it is only in the sense that it has always proved

possible to find such laws that one speaks of scientific laws or of the "Laws of Nature."

Clearly all this bears directly on the general relationships called "cause and effect." Although the older, mechanical-materialistic interpretation now finds its applicability considerably restricted (by the uncertainty principle, by the importance of multiple causation, by the statistical fields), it still plays a large part in thinking, and it still provides the simplest weapon against animism, anthropomorphism, teleological thinking, and the pathetic fallacy. That the adolescent who consistently uses cause-and-effect relationships to build up his world picture will have to make several serious revisions later is true, but the step from pre-logical or magical explanation to causal explanation is certainly a progressive one, and the later qualifications are hardly in a state to be used directly.

The habit of looking for causes for important effects is one that can be developed in connection with *any* science situation. Tests may be constructed in which the adolescent is confronted with a science problem and with a list of plausible-looking answers, ranging from direct appeal to prejudice and emotionalized attitude, through folklore and common-sense answers, to scientific laws. By shuffling such a list and asking students to choose all the answers that have a real bearing on the problem it should be possible to determine the consistency, as well as the general slant of each student's habit of mind. Such a test will also give valuable indications to the teacher of what to emphasize and what to skip over. Later tests of the same kind will help in judging the effectiveness of the teaching.

Just as the antithesis, uniformity and variation, provides a summary of many problems in the field of evolution, so the inanimate, physical-chemical world presents the physicist with an extremely *varied* set of data and characters, among which he tries to discern *uniformities*. He looks for *invariants* or for quantities that are *conserved*. Confronted with an extremely complex physical world, he has a choice: he may try to dis-

cover the laws (themselves surely very complex) that describe the crudely observed facts, or he may look for properties and quantities (possibly obscure and generally very abstruse) which are describable by comparatively simple laws. The physicists have shown no hesitation in choosing the second alternative, which carries with it the obligation to show how the more abstract quantitative properties are related to the observed, simple properties. Several of these quantities have already been isolated and found useful. Among the most important are energy, entropy, matter. With the accumulation of data over long periods of time each of these has become a rather complicated concept, but they are nevertheless retained because the laws describing their changes are comparatively simple.

One of the basic laws of physics is the Law of the Conservation of Energy: energy can neither be created nor destroyed, but it can be transformed from any one form (mechanical potential, mechanical kinetic, heat, light, sound, chemical, electrostatic, electromagnetic, radioactive) into another in exactly predictable ratios. The teacher must not presume that the statement of this law in this form implies either devoting a full year to demonstrating its validity or taking up all the topics of the standard physics course. Quantitative demonstration of some of the easier transformations is more effective in unifying the field of physics for the student than is a systematic survey presentation. After a few such demonstrations, reading, plus the indication of suggestive examples from the student's own life (in common machines, in his own body, in the organic world), will accomplish the purposes here envisaged.

For younger adolescents, a corresponding set of experiments on the law that "matter can neither be created nor destroyed" will probably be found more appropriate. The answers to such questions as "What becomes of the candle when it burns, or of the food we eat?" will provide the basis on which to lay the generalization.

The Machine Age. This has been appropriately called a machine age, and this fact alone is a supporting factor in the case for including energy among the concepts basic to an adequate world picture.

It is possible to study a few machines and to learn much about the laws of physics, about the way physicists think, and about the part that engineers have played in making modern life what it is. In fact, the Committee believes that many teachers will find this the most promising way of coming at the problem of world picture and philosophy of life in so far as these are affected by the ideas and material products of the physical sciences.

Understanding a machine may be taken to include three major steps. First, one must be able to dissect and to reassemble one. Second, one must be able to trace the flow of energy and matter through the machine, including all energy transformations. (In this step most adolescents will require a good deal of help from the teacher.) Third, some analysis must be made of the way in which the properties of each part of the machine are suited to its function—the way in which each part is so made as to facilitate certain energy transformations and to minimize others that are unwanted. Such a generalized study of a machine as this, plus the detailed manual skill that must be developed in assembling and in measuring, provides an adequate summary of the point of view and state of mind of the engineer, and at the same time gives the adolescent a sense of the importance of design, forethought, planning, experimentation, measurement—in a word, a sense of how scientific laws are used for prediction and for control. Only those things are left to chance which cannot be controlled. Everything which can be foreseen is provided for.

A group of simple machines and a group of more complex ones may be cited as suitable for this kind of study. Some teachers may think that machines like locks, bolt and nuts, pencils, pins, electric light bulbs, water faucets, will not excite enough interest in their students to provide promising educational experiences. On the contrary, for young adolescents—particularly if they live in a town where one of these objects is being manufactured—a short study following the general scheme outlined above may well provide a suitable basis for the study of more complicated machines. Again, it may seem to some teachers that reflective thinking,

appreciations, creativeness, or readiness to act on the basis of tentative judgments are too fine-sounding to be applied to whatever is happening to the young adolescent who is studying a water faucet. But suppose as a result of the dissection of several faucets it is found that there are two kinds of faucets, one kind easy and the other kind harder to turn on and off; that all faucets contain a soft washer seating on soft metal; that with a small effort it is possible to control water pressures up to eighty pounds per square inch; that some faucets make the pipes pound and others do not; that all faucets have two water-tight packings; that the water faucet is the type of all valves with which a small amount of energy is used to control a large amount (just as in the case of the electric switch, the electron tube, the thermostat, and the spark plug). In the hands of some teachers, at least, these discoveries may contribute to some of the characteristics mentioned.

The electric motor, the automobile, the radio receiver, the motion-picture projector may be mentioned as examples of more complicated machines. The Committee does not propose that a preliminary course in physics is desirable, but it does hold that the teacher in sympathy with the point of view of this report may help the student develop the values it prizes in the dissection and assembly of an automobile, for example. The complex interconnections of the many systems that make up the modern automobile provide an excellent opportunity for a study of engineering integration in the small. Considerations of comfort, of quiet, of mechanical efficiency, of speed, of safety have all played their parts and have all been compromised with. The gasoline and exhaust flow, the transmission, the electrical system, the streamlining all interlock and modify each other. From the part that turns kinetic into heat energy (the brake lining and drum) to the part that turns heat energy into kinetic energy (the cylinder and piston), no pains have been spared to find what substances and shapes would facilitate the energy changes wanted at that point and minimize those that are not wanted.

A similar study of the radio receiver is of great interest to older adolescents, and the mechanical analogues of the four parts of the radio set (resistor, capacitor, inductor, vacuum tube) can be used to indicate how the set was developed, how it works, and how it is related to the rest of the engineer's world.

The forms of energy in "mechanical" machines (say in the automobile after the initial combustion in the cylinder) are classified as kinetic, potential, and frictional. Similar forms occur in the radio set. The inductors are strictly analogous to mechanical masses—that is, they may store electromagnetic energy analogous to kinetic energy. The capacitors are analogous to springs or other storers of potential energy. The resistors, changing electromagnetic energy into heat, are analogous to the frictional parts of the mechanical system. The mechanical idea of the valve, a device for using a small amount of energy to control a large flow, finds its analogy in the vacuum tube which serves the same function electrically. Though not all adolescents need to know how a radio set works, clearly a treatment such as that indicated will help to integrate the student's knowledge of the radio with his other knowledge, to give him a hint of how the scientist thinks, and to make intelligible one of the major household mysteries.

Evaluation of an adolescent's understanding of the idea of energy and of the way a machine works (for those teachers who judge this to be a valuable understanding) is particularly easy when the teaching is done in the manner suggested. The work done is itself a large part of this evaluation. A test situation with an unfamiliar machine, reports on the effects of new machines on the standards of living of different groups, tests on ability to apply principles can also be used to evaluate this work.

After, or along with, such a study as the one outlined above, the science teacher who is concerned with his students' developing philosophy of life will want to discuss some of the ways in which each of these machines has made differences in their own lives. The auto has made life more dangerous for all and more comfortable for some. It has had direct effects on suburban living, on love-making, on buying habits, on drinking, on vacationing, and so on. The radio need only be mentioned for a dozen important modifications of habits of life to spring to mind. The motion-picture projector has had far-reaching effects on prevailing conceptions of acceptable moral standards in love-making, in achieving success, and in other areas.

Efficiency (Minimum Energy, Maximum Control)

A fourth idea from the realm of natural science that has played a large part in the determination of the modern temper is that of efficiency—the efficient use of energy and the efficient use of matter. As applied in engineering this word generally involves a normative judgment. Efficiency is defined as the ratio of energy that does *useful* work to the total energy put into a process. This idea has found some of its most useful applications in the field of economic-industrial life,[9] but the notion that it makes a difference *how* the individual does even his daily chores already implies a concern with saving time, being less fatigued, being less disturbing to others—in short, with being more efficient. It has been said that the touchstone of integration of personality in the modern world is the way the individual controls and apportions his time. The idea of saving time is part and parcel of the idea of efficiency.

But the efficient use of matter has more profound implications for the development of a world picture. The study of the properties of the elements, and of their chemical compounds, has given chemists the power to produce substances with a wide range of *useful* combinations of properties. It is a commonplace, but an important one, that the material culture has been greatly modified by chemical creation and discovery. On every side there are new foods, flavors, textiles, dyes, alloys, plastics, explosives, fuels, drugs, and disinfectants, all of them the products of the chemists' skill. Detailed study of all these new products in chemical terms is not advocated, but the study of one or two, say fuels and plastics, provides an ample basis from which to point out what these new substances are doing and what they might do to modern life.

There will be some students for whom the intellectual implications of the larger laws in chemistry will be of value, though they will not constitute a desirable field of study for all adolescents. Chemistry is becoming a unitary science, with

[9] See Chapter VI for a discussion of the concept in this relation.

only a few laws in which larger and larger bodies of facts are summarized in convenient (and therefore more efficient) form. There will be some few older adolescents for whom a study of the periodic table, combining proportions, and the laws of the energy changes in chemical reactions will provide a significant part of a world picture. Here, too, the combination of *diverse* appearance under *uniformizing* principles is to be emphasized.

Probability and Statistics

The frequency with which judgments, hypotheses, beliefs, and even statements of fact must be qualified by some such phrase as "in all probability," "the chances are," "when all the facts are known," "in general we may suppose," "of course there are exceptions," and the like, attests to the necessity for a clear understanding of the extent to which these qualifications diminish or modify the significance of the statements made.

But it is only the relatively sophisticated person who can use even these forms of qualification consistently. More frequently judgments are qualified only implicitly, and in ways which seem and seek to carry more conviction than they really merit: "Insanity, like blue-eyedness, is inherited"; "The people of the United States are more practical than the French"; "In the year 2,000 the population of the United States will be 200,000,000 if the present trend continues"; "The normal American adolescent has an intelligence quotient of 100." Such examples abound not only in conversation but in the serious thought of almost every adult and adolescent.

All of the types of judgment of which the above statements serve as examples have to do with *groups* of individuals, with *collections* of events. Since so many of the inferences that every one is called upon to make are only probable inferences, and since many of them have to do with the properties of large groups of individual elements, some knowledge about the rules of probability, inference, and the general attributes

of large groups seems indispensable to well-considered action.

Originally statistics were facts about the state, and it is still true that facts about the state are statistics. The simplest facts about a state are generally totals or averages. Averages generally tell more than totals about human values. Thus the total wage fund of the United States (11.6 billions in 1929) seems large, but not much use can be made of this fact without knowing among how many people it is divided (8.8 millions in 1929). The average wage was, then, 1,300 "1929" dollars, and this number can be used by the adolescent in thinking about standards of welfare, about his own family's status, and about other problems that concern him directly.

Often the adolescent uses the word *average* to refer to the average of his own numerical grades given in school. He knows that some of his marks are above this and that some are below; he knows that one very low mark will pull down his average enough to threaten his self-assurance. He knows that his teachers are interested in this average, but also that they are interested in the particular way in which his individual grades are distributed around it. He is interested in knowing how many in his class have averages below his, and how many above. He probably feels that he is "normal" if his average is equal to or above the class average. He feels the same way about his height and weight.

The teacher who agrees with the treatment of normal adolescent development summarized in the section on "Opportunity to Gain a Sense of Proportion through a Functioning Understanding of Normal Variability" (page 95) will be able to explain that what is normal for a *group* is a *distribution* of every variable character (including of course many often thought of as constant, such as body temperature or the periodicity of menstruation). Similarly, what is normal for an *individual* is a *distribution* of his various characters, some above, some near, and some below the average for a large group of his age-sex mates. Though for some symmetrically distributed characteristics a single number like the standard

deviation or the probable error suffices to give an indication of the distribution, it will be of frequent value for the adolescent to know about some of the important distributions that are very skew and that therefore are most easily remembered as graphs.

In brief, the average and the distribution around that average are two of the most useful data one can have in thinking about any of the characteristics of a population (or group or table of data), or about the group of characteristics of a single individual.

Next in importance for clarity in thinking come trends, that is, information on variation in time. Growth curves, population curves, trends in real wages, production and productivity curves provide basic data for accurate thinking in each of the basic aspects of living. The criteria for extrapolation of temporal trends should be dealt with.

With increase in populations, and with simultaneous increase in power and material productivity, large numbers have become necessities for thought in many areas. The daily papers supply a great deal of their information in this form. It is an urgent necessity for the youth growing up to be able to remember and use some of these large numbers in simple arithmetical operations. Similar necessity exists in astronomy, in economic engineering, in genetics, and in many other parts of the exact sciences. The ability to estimate simple ratios of large numbers provides much of what is needed here. Ability to divide by 100 million is easier to teach and will be more often used than long division. A sense of proportion is well implemented by some facility of this sort: the newspapers frequently present totals (taxes, unemployed, insurance, savings deposits, and the like) when per capita or percentage information would be more usable.

Closely related to the arithmetic of large numbers is the problem of approximation and precision. The adolescent as layman will rarely need data accurate to less than 5 per cent, and yet some considerable part of his school life is commonly

taken up with learning processes in arithmetic and algebra that seem to have unlimited precision. Most of the statistical data he will use need not be known more closely than within 30 per cent, and he should learn to be at home with numbers of this precision and to know how to make simple calculations with them. Some teachers will even be able to show him the spurious accuracy of grades refined to within 1 per cent, the meaninglessness of a census apparently accurate to one part in a hundred million, the limitations of accuracy of all physical laws that are not definitions, etc., etc.

Questions of non-numerical accuracy can be handled in the same way. When it is said, for example, that a certain person can give an unbiased judgment on some question, it is important to know that no absolute is implied, but rather that his judgment is known, on the basis of past experience (that is, on a frequency basis), to be less biased than that of other people. Similarly it can be shown that a group of equally well-informed persons probably has a less biased collective judgment than a single member.

People make most of their judgments on the basis of samples of experience from their own past. The question of the extent to which such samples are representative of the total mass of experience is difficult to answer, and yet sensitivity to this source of inaccuracy and error is important. Are the mice used in the laboratory typical of mice in general? Are the two Frenchmen who visited the school typical of all Frenchmen? In all respects? The general question of the comparability of distribution of a sample and of its parent population can rarely be approached in mathematical terms by most adolescents, but some awareness of the diminution of reliability that is bound to occur when this factor cannot be evaluated ought to be made part of the equipment of all.

Operational Thinking

Operational thinking is not a new way of thinking, nor is it a system of thought in itself. It is a term used to emphasize

certain aspects of reflective thought often lost to view in the welter of verbalization that usually accompanies discussion of scientific methods and reflective thinking. Practice in the use of operational techniques, with their insistence on connecting common nouns with things and abstract nouns with sets of operations, can be most easily supplied in the natural-science area. Although this technique has so far been developed mainly in the field of physics, it would seem to have applicability in other areas.

Discussion of some ways in which this mode of thought (an aspect only of reflective thinking) may be of considerable help to the adolescent in forming both his world picture and his philosophy of life, is deferred to Chapter VII.

Typical Generalizations

(For a discussion of the proposed uses of these generalizations and their limitations, see page 85.)

1. One of the fundamental questions that each person must ask and answer at each stage in his development is: *Which authorities and what kinds of authority do I accept, and which do I reject?*
2. The evaluation of authorities is a large part of the scientific method for laymen as for scientists.
3. Knowledge is steadily developing; truth is partial and never final; authorities shift for the race as for the adolescent himself.
4. There is nothing knowable that *may not* be known (that it is forbidden to investigate).
5. Biologists have been able to arrange the plants and animals, living and fossil, in large groups (phyla) such that the species in each group show important resemblances.
   a. From the lower to the higher forms of life there is an increasing complexity of structure, and this is accompanied by a greater internal division of labor.
6. The power of the idea of evolution by natural selection, and of the opposition to this idea, was largely due to its success in describing the complex facts of the organic world without

assuming any outside agency or any purpose, but only the discovered and discoverable uniformities of nature itself.

a. Scientists assume, in investigating any piece of human behavior, structure, or function, that whatever an organism does, is, or becomes, is the result of genetic and environmental factors.

b. The laws of physics and chemistry are presumed to apply inside organisms just as they do outside.

7. The laws that describe inheritance in plants and animals are essentially the same as those that describe inheritance in man.
8. Every expressed character of an individual is the product of the interaction of hereditary and environmental factors.
   a. There is no such thing as heredity separate from environment. All hereditary characters require an environment in which to show themselves. An important part of the environment of each hereditary factor is the presence of all the other hereditary factors.
9. The basic mechanisms of heredity have been and are being deduced from the statistical results of breeding experiments, supplemented by cytological study which is demonstrating a physical basis in the chromosomes for interpreting these deductions.
   a. Thousands of characteristics of lower plants and animals, and dozens in man, are already known to obey the same simple statistical laws, called Mendel's. These characteristics in a constant environment do not show continuous variation.
   b. Many characteristics presenting continuous variation, in man and in other organisms, are presumed to be due to the combined action of a number of hereditary factors, each obeying Mendel's Laws.
10. The advance of the biological sciences and closely related physical sciences in the past century has profoundly affected the world picture of most of those who understand this advance.
11. Cosmologists are increasingly successful in their attempt to present all the observed facts of the physical universe in the form of a few descriptive laws.

a. Teleological arguments are not acceptable in modern cosmology.

b. All that is known about the past of the earth is compatible with the assumption that the laws of physics and chemistry are generally applicable.

c. Evolutionary processes are characteristic facts of the universe.

(1) Galaxies probably pass through a development from thin nebulous matter to the concentration of this matter in stars.

(2) Certain nebulae are at present in a stage of development through which our own galaxy probably passed.

(3) Stars probably pass through a sequence of development, characterized by changes in size, brilliance, and composition.

(4) The earth and the other planets probably resulted from a close approach of the sun and another star.

12. Man's conceptions of the nature and structure of the external world constantly change.

a. The body of physical knowledge is cumulative and progressive, much that is learned depending on previous work.

b. Change in world picture rarely results in denying particular observed facts formerly thought certain but rather in changing a framework so as to include more observed facts than the older theory.

13. Natural science has often furnished material to great literature that deals with human emotions and character; this literature continues to have literary and spiritual value after it has grown old, but the science with which it deals often becomes obsolete.

14. Every observable object and all observable parts of an object obey the fundamental laws of physics.

a. Energy can be neither created nor destroyed, but it can be transformed from any one form (mechanical potential, mechanical kinetic, heat, light, sound, chemical, electrostatic, electromagnetic, radioactive) into another form in a predictable ratio.

b. In every transformation of energy, some goes into heat and thereby becomes less available.

c. Matter can be neither created nor destroyed.

15. Machines exemplify the control man has or may have over the inorganic environment.
    a. Understanding a machine includes some ability to dissect and to reassemble one (auto, motion-picture projector, radio, electric motor).
    b. Understanding a machine includes some ability to trace the flow of energy through it, including all energy transformations.
    c. Understanding a machine includes some appreciation of the way in which the properties of each part are fitted to its function.
16. The study of the chemical elements, and of their compounds, has given chemists the power to produce substances with a wide range of useful combinations of properties.
    a. Our material culture has already been greatly enriched and modified by chemical creation and discovery (new foods, flavors, textiles, dyes, alloys, plastics, explosives, fuels, drugs, disinfectants).
    b. Chemistry is becoming a unitary science, with only a few general laws in which larger and larger bodies of facts are summarized in convenient form (periodic table, free energy tables, combining proportions, atomicity).

THE NEED FOR A RANGE OF PERSONAL INTERESTS

Any of the science topics and science activities indicated in the preceding sections of this chapter may serve as the basis for developing personal interests. There will be great variation in the way this information will be taught, in the way it will be learned, in the characteristics of personality which will be fostered in the process. But in addition, a few young people will want to devote a week to some topic on which most will want to spend an hour; some will want to skip the whole thing; and an occasional one will want to make just that thing his life work. The teacher must make provision for this kind of variation: every student cannot be satisfied as to the apportionment of class time, but every student who is inter-

ested in something in particular can spend time of his own on just that thing.

Clearly the young person's choice will play the largest part in the determining of such an interest, which may develop in the area of science immediately or may move toward the sciences from some other area. But good teaching teems with stimulating suggestions and with avenues along which these more personal interests may be pursued.

Intellectual interest in science topics growing out of class work or outside experience constitutes the most familiar type of personal interest. Almost any science topic may be thus developed. The student is interested because he wants to find something out, wants to know more about something; his interest is in large part intellectual; and though its pursuit may involve much more than reading, any laboratory, constructional, technical, or other work that he may do in connection with it is incidental to his purpose. Such an interest may well result in the production of a monograph, an essay, a digest of books read, a summary of experiments done, places visited, persons interviewed.

Construction, collection, craft, "production" interests may be differentiated from those indicated above in that the adolescent's objective is to make something, to see if he can build something, have something to show, something to keep. Such interests often start suddenly and often terminate with the accomplishment of a simple aim. The construction of models, charts, maps; the building of a shop or home laboratory; animal breeding; photography (still and motion); gardening; collections of all kinds (leaves, minerals, insects); making birdhouses, aquaria, terraria are examples of these interests.

Interests connected with the graphic arts may often be suggested by the science teacher, or he may foster them when they originate elsewhere. Murals with science subject-matter and the preparation of scientific drawings are finding an increasing place in progressive teaching, and some students who are primarily interested in the arts may develop an interest in the new tools and materials with which modern science is providing the artist.

Organizational interests may also find their main focus in science and may be suggested and developed with the help of the

science teacher. Science clubs and science committees for the application of science principles in the school (heating system, ventilation, lighting, noise reduction, electrical machinery, public address systems, phonographs, and radio receivers) may be of great service to the school at the same time that the small participating group learns to assume more mature responsibilities.

Student excursions, field trips, outside investigations, nature study, seashore trips, and the like may often be expressions of personal interests which go very deep and promise to become lifelong avocations, or they may constitute only temporary digressions. They are to be encouraged in either case.

Demonstration projects for other subject areas may well become an important factor in facilitating correlation among the various areas of instruction in the school. Students of physics can set up interesting and instructive models and charts for classes in music, geography, speech, civics, physical education, etc.

THE NEED FOR ESTHETIC SATISFACTIONS

In discussing general education in terms of the needs of adolescents, the Committee is very anxious indeed to remove from the word *esthetic* its occasional connotation of being the property of a wealthy few. Also, the word should not apply only to something that happens in museums; beauty may be found in many places, if only teachers and students be shown how to look for it. Again, it will be noted that stress is not placed on the appreciation of beauty that often accompanies, at the adult level, the contemplation of the works of genius. This form of appreciation in general requires more knowledge of subject-matter and more skills than will be in the possession of most adolescents. It is all very well to speak of the genius of Newton, but very few young people—and for that matter, very few teachers of science—will have the time to acquire the background and the technical skills necessary to the esthetic appreciation of his kind of genius.

Although several kinds of experiences which provide esthetic satisfactions are discussed below, it is not to be supposed that each adolescent must acquire the same measure of esthetic

satisfaction from each. As variety and richness of perception provide the background for esthetic satisfactions so must the teacher of science prepare for considerable variety and richness of individual treatment and response.

Many teachers recognize the frequent occurrence of a type of student behavior that can be attributed only to a need for some sort of esthetic satisfaction. Every teacher has seen adolescents "get a kick" out of doing an experiment, building a model, proving a geometry original, reading about an invention—a "kick" that seems somehow immediate and not analyzable beyond the designation *esthetic response*. Calling a response esthetic links it to responses of satisfaction observed elsewhere, particularly in reaction to the production and enjoyment of art objects.

The Committee is not concerned to develop a theory of esthetics but only to list some types of esthetic satisfactions that may come to accompany the adolescent's work in science, and to suggest some ways in which these appreciations may be refined and applied to life situations. It is not important to make students themselves aware of the fact that their teachers are concerned with esthetic satisfactions, classifying and identifying them. Such a course may lead to self-consciousness on the part of the student and even to rationalization for sheer inactivity or day-dreaming. But this classification of needs should help science teachers arrange their teaching so that more esthetic satisfactions may be derived from school work in science, and so that appreciations may be refined and enhanced by it.

Sharp distinctions between means and ends are rarely justified, and in the field of esthetics even more rarely than usual. Whereas artists, esthetes, and estheticians, on the one hand, seem to make the appreciation of beauty an end in itself rather too often and too dogmatically, science teachers and operationalists, on the other, are apt to insist that the importance of a satisfaction be judged solely in terms of its effectiveness as a cause of further purposeful behavior. No, some satisfactions

are ultimate, at least in the sense that the satisfied person wants to do nothing more about them, sometimes not even to extend their duration. Teachers who are aware of this fact will not worry too much about the occasional periods of inactivity and passiveness that come over many students as they achieve satisfactions of this sort. They will distinguish harmful fantasying from genuine appreciation of esthetic qualities and prize these latter, encouraging them for their worth to the student.

Workmanship, Fitness, Originality, Creativeness

Teachers often hope that their students will appreciate the neatness, efficiency, fitness, or elegance of scientific thinking and of some scientific constructions, and some teachers succeed in helping them achieve such appreciation. But it is generally asking too much to expect students to develop these traits to a very high degree in their own productions (papers, note-books, laboratory set-ups, models, and the like), and genuinely esthetic values do not lie in mere tidiness. It seems to be generally true that students whose note-books are paragons of neatness rarely show originality or even moderately superior habits of reflective thinking; they tend on the contrary to be docile, to type out sections from textbooks, and to have an excessive taste for repetitive routine. A feeling for neatness of this sort is not an appreciation to be highly valued.

It is not that the adolescent who tends to make a fetish of routine neatness should be looked down upon; his routine gives him satisfaction and even security which one would not wish to take from him. But it may be possible to help him to more creative production at his own level by giving him a very simple project or problem that is completely new to him, and for which he cannot copy. The science teacher should show his interest in and approval of the simplest job that an adolescent does with some measure of independence, so that he can honestly say that it is his own work. The problem is to find projects that are both interesting and simple, for unless they are interesting the student will not spend enough time on them

for his pride of workmanship to develop, and unless they are simple they will require too much technical skill or teacher help. Workmanship does not necessarily imply the development of craft or laboratory skill; quite unskilled adolescents can get satisfactions properly called esthetic from the accomplishment of jobs that require care, foresight, finish, attention to detail—all the old handicraft virtues, in fact, save technical skill.

In contradistinction to mere routine tidiness, the science teacher should be concerned not only with creative workmanship, but with other forms of originality as well. It is his responsibility to develop a preference for direct as against indirect solutions of problems, for pure functionalism in design as against irrelevant importation of old-fashioned decoration and shape, for the shortest proof as against a longer one, for crucial experiments rather than experiments that *may* indicate something, for short methods in arithmetical calculations as against indiscriminate long division and multiplication, for calculations that take account of the accuracy of data rather than for the meaningless carrying along of all the minute fractions which are without significance for the problem.

Preferences of this sort are developed and their accompanying satisfactions achieved only when students have a chance to try out several methods in each case. It is rarely sufficient for the teacher to demonstrate the superiority of the "right" method. Students often have their own, privately developed methods, worthy of friendly discussion and comparison by the class. This sort of discussion—accompanied by the performance of the same experiment in several ways, with alternate proofs put on the board simultaneously and separate calculations made by the users of the different methods—will do more to facilitate this sort of appreciation than will dogmatic (even though correct) presentation of a single "best" method. In the course of this process the teacher and some students must of course take the time to teach the others more efficient procedures when the latter want to learn.

It is clear that this way of teaching takes far more time to cover a given amount of "ground" than does a systematic exposé. But this time is not only well spent in the development of esthetic appreciation; even from the point of view of time-efficiency, such a method is superior in the long run, in that students who have been using less efficient methods for years will not take over shorter ways of solving problems and of calculating unless they are convinced by their own practices that they cannot afford to spend so much time on work that is really needless.

Thus science teachers will encourage neatness only when neatness helps to accomplish the adolescent's aims. If his aim is to make a piece of apparatus that works, then only that neatness which makes the apparatus work better is desired. If his aim is to produce a machine (or a collection, or a proof, or a paper) that is to show some principle to others, then neatness will be a virtue in so far as it facilitates the demonstrative effect, and this sort of effectiveness will be appreciated by the adolescent himself.

It is for such reasons as this that students "like" direct experiments much better than the indirect ones so typical of the present science syllabi. Newton's first law of motion is not interesting and will not be retained or used by adolescents if all the machines they see, and all the experiments they do, provide cases where bodies do *not* move in straight lines with uniform velocity. The concept of mass remains an unusable abstraction if all the experiments done involve weights, and if forces are generally also measured by weights. Directness is a characteristic that adolescents appreciate, and this sort of appreciation should be given more consideration by science teachers. Only then will students see the point of the sort of functional neatness, efficiency, or evident fitness under discussion here.

Efficiency, Comfort, and Luxury

When the adolescent boy says that a new, powerful automobile is a "beauty," he means that it does certain things ex-

ceptionally well and that he likes the way it looks. It can accelerate fifteen miles per hour per second; it can move steadily at eighty miles per hour; it can stop faster than it can accelerate; it is practically independent of external conditions (with windshield defroster and wiper, with heater and ventilator, with balloon non-skid blowout-proof tires, with cigarette lighter and radio receiver, with automatic choke, thermostatic radiator, non-freezing cooling fluid, etc., etc.); it is heavy, low, made of steel and non-shattering glass, so that it shows its superiority even in collisions. The boy who notices and values these things is appreciating the fitness of the automobile as a machine that functions in desirable ways.

The science teacher would do well to help the boy see that many of these functions are actually not desirable, either socially or personally; that the high acceleration and the high maximum speed of many modern cars can almost never be actually used, owing to traffic and road conditions; that braking power has by no means kept pace with engine power; that ability to survive accidents has partly been attained by decreasing visibility and increasing danger to other cars and pedestrians, thus increasing certain kinds of accidents.

But changing the student's criteria for usefulness must not change his appreciation of usefulness when this has been redefined; care should be taken to preserve the fundamental criterion of usefulness as one legitimate meaning for the word *beauty*. The boy is prizing efficiency as he sees it, and though there are important respects in which his notions of efficiency may well be modified, his feeling that a job well done is more satisfying than one done with less efficiency is fundamentally valuable and should be preserved. An automobile that could accelerate rapidly, but that had governed driving speed, that was economical in the use of gasoline and oil, that had maximal visibility for driver and passengers, that would automatically slow down as it approached any solid object would be a beautiful car.

Appreciations similar in kind can be fostered in connection

with the student's own work in laboratory, shop, library, and classroom. They certainly apply to most of the machines in which adolescents may be interested. The manifold application of such considerations to the modern radio receiver, for example, would do much to encourage study of this machine and would facilitate rather than hinder the attainment of many other general aims of science teachers. Most people do not realize how little of the receiver that they buy is actually functional, nor are they prepared to appreciate the beauty of the naked chassis, but this is largely a matter of miseducation by cynical or unimaginative manufacturers and promotion departments.

The boy appreciating the automobile also likes the way it looks. What does he like about it? It looks comfortable, even luxurious; it has highly polished and finished fittings; it has dozens of gadgets; it looks very big and very expensive; it looks up-to-date; it looks "smooth." Some of these appreciations are due to identifications with a leisure class *via* conspicuous expenditure. Considerations of this sort play a large part in the actual lives of a few adolescents and in the fantasy world of most, but their necessary connection with esthetic satisfaction is to be doubted.

Chromium-plated, ten-inch door handles need only be mentioned to be ruled out as legitimate stimuli for this sort of satisfaction. The endless gadgetry that occasionally afflicts automobile design has obvious purposes which have little to do with genuine esthetic values. Part of the student's reaction is due to advertising which capitalizes upon the leisure-class fantasy, testimonials by revered persons, pseudo-scientific tests, and success as measured by sales. These meanings are to be deplored and devalued, and the science teacher is in an excellent position to do this.

Adolescents can understand Veblen's analysis [10] of the social psychology of conspicuous expenditure and of its adverse ef-

[10] Thorstein Veblen, *The Theory of the Leisure Class* (New York, The Viking Press, 1924).

fects on those less "privileged," and it should do much to clear their minds for a more honest approach to lasting appreciations.

Orderly Form and Orderly Activity, Repetition

Esthetic satisfactions also arise with the perception of simple forms of order. Important among these forms are symmetry, analogy, and familiarity. Symmetry in algebraic equations, reversibility in physical dynamics, symmetry in biological structure, balance in machinery, geometric symmetry, the dual propositions of projective geometry, provide examples that can be used in teaching.

The celebrated physical analogies (for example, between a lever and a transformer; between electrical inductance and mechanical mass; between linear standing waves in strings, in vibrating air columns, in Lecher wires, in water; between diffraction patterns of sound, light, water, and radio waves; between electrical capacitance and mechanical compliance; and so forth) are appreciable by adolescents if time is given them, and if—at the very least—parallel demonstrations of the sorts indicated are set up by the students themselves, each group working on the demonstration that most interests them.

Incidentally, many adolescents enjoy intensely solving the problem of making difficult things they have been studying clear to outsiders, and this sort of appreciation is clearly related to that of evident fitness, purpose shown by form, demonstration efficacy, referred to above. Older adolescents derive considerable satisfaction from projects designed to demonstrate some of the analogies mentioned above before a more general adolescent audience.

To speak of familiarity as a form of order might appear to be giving a fine name to a common happening, but it serves to emphasize the value of the feelings that every one has about familiar things. If adolescents are given time, as they so rarely are, they will be found repeating experiments that they like, making a machine repeat its operations many times, doing

dozens of problems all of the same type, carrying out long division to ridiculous lengths, and so on. To dismiss these behaviors as childish is as mistaken as to become alarmed over them as compulsions or obsessions. They may be childish, but they are still serving purposes for the adolescent which he cannot at the moment serve in any other way. They may be compulsive, but the teacher can guess after observation whether the young person is killing time, stalling to keep from doing some other needful work, or is deriving some needed satisfaction from the repetition and perhaps also learning more and more about the operations by observation, variation of operating conditions, or other means.

Adolescents like to have things come out in the laboratory as they are described in the laboratory manual; they like to be able to predict what will happen and then to see it happen; they may even like to repeat an experiment that came out as predicted the first time, for the sake of seeing it come out again. This sort of liking is also, within reason, to be not only tolerated but respected.

Sensation, Richness and Variety of Perception

Some teachers feel that the dignity of their subjects is impugned by suggestions to include experiments and demonstrations that rely upon immediate sensation for their effects. They feel that the spectacular thermite mixture, the magnesium ribbon burning in oxygen, the smell of hydrogen sulphide, the discharge of a Leyden jar, the explosion of a hydrogen-chlorine mixture in light, make their effect too cheaply. Though it must be agreed that demonstrations of this type may be performed merely for momentary effect, they may also be performed to drive points home, or for fun, or more especially for the sake of opening avenues of perception generally neglected in all the other aspects of the adolescent's life. Smells, for example, are meaningful to most adolescents only if they are connected with food, with "perfume," or with objects toward which disgust is supposed to be appropriate, and

too much of young people's experience nowadays is similarly impoverished for lack of a rich perceptive background.

This might be rectified a little by science teachers who see that those experiences may be richest that involve perception of different kinds, and who know that it is not repetition, but wealth of context that facilitates learning and enriches living. Such teachers will not hurry the adolescent who wants to do a striking experiment over a few times. They will know that he is very likely doing something he enjoys, and they will respect that enjoyment, even though it may be "cheap" from an adult scientific point of view.

A further avenue of enrichment and variegation of perception is to be found in field trips, visits to factories, mills, mines, and the like. It goes without saying that such trips may well serve also as integrating centers and as sources of material for literature, social studies, and the arts as well as for science courses.

Relatedness, Synthesis

Students should be given ample opportunity for unfamiliar experiences but at the same time there is value in letting them have familiar experiences over and over again. There is no inconsistency here; both are possible sources of esthetic satisfaction. But there is a further development of the second of these that is often appropriate for older adolescents interested in making sense of their natural world, namely, the development of new connections between components already familiar.

To be sure, such a development serves important intellectual functions as well, but the esthetic satisfaction that comes from such integrations is worthy of special attention. The analogies inside a single subject-matter area, such as those in physics mentioned above, often provide just this kind of satisfaction. The range and power of simple concepts from mathematics (particularly from statistics and from geometry) will strike some, though not all, adolescents.

The Beauty of Natural Things

The preceding sections have discussed the possibilities of developing appreciations in science work, but in the main the objects of appreciation considered have been man-made. Some teachers will consider it easier to develop appreciations in connection with natural things. Most adolescents appreciate some natural things in the sense that they look at them repeatedly and think of them often, without feeling any need to analyze or to note relationships. But the perception of new relationships tends to enhance appreciation, and the science teacher may do a great deal to point out such connections. It is well known that students of art and art history show appreciation of many more kinds of art objects than those who have made no such study. If the study results in loss of appreciation for a few, simple (or vulgar) types of beauty, this can hardly be considered a loss, since more appreciations at other levels are usually added. Enjoyment of sunsets is not diminished by a knowledge of refraction and dispersion; a meandering stream is not less but more attractive for the adolescent who understands Beer's Law and Corioli's forces; mountains do not become less interesting by reason of the additional knowledge of the mechanisms of folding, erosion, and isostacy; the pretty-girl magazine cover may mean different things to the boy who knows a little about color printing, about biology, and about advertising psychology, but these do not diminish his appreciation. Beauty is not a property intrinsic in certain objects and intrinsically excluded from certain other objects. On the contrary it inextricably involves human appreciation, and breadth of knowledge and association are essential ingredients to lasting appreciations.

Appreciation of beauty in the organic world has for many years been associated with nature study in the elementary schools. The Committee proposes the extension of this work into the secondary school in connection with the teaching of science. It has often been pointed out that the modern study

of evolution (the study of populations, of the mechanisms of selection, of ecology, and of comparative embryology rather than the older emphasis on paleontology, comparative anatomy, and taxonomy) is really nature study, and these are some of the areas in which extensions may be sought. The aim here is not to add to the list of animals and plants that may be called beautiful. Rather it is to develop appreciation for animals and plants already admired by showing some of the many things scientists have come to know about their origins and life histories, and about their behavior as individuals and as populations.

Science teachers can do a great deal to help adolescents develop appreciation of human beauty, particularly bodily beauty. The young person tends to think of beauty mainly in terms of shape, texture, and color, and in terms of standards he imagines to be rather invariable. Science teachers, particularly those with some knowledge of anthropology and of the history of art, can widen the scope of appreciation of their students by showing the wide variety of human forms considered beautiful by primitive races and by civilized people of present and of former times. The part played by applications of science—public hygiene, the abolition of smallpox, balanced diets, exercise, fresh air, light clothing for girls, the control of syphilis, the control of acne, new and cheap textiles, beauty culture, and a dozen other relatively recent developments—in changing ideas of human beauty, as well as in standardizing these ideas, can well be brought out by science teachers.

Teachers are also in an excellent position to emphasize appreciations of function as well as those of form. It is no accident that the word *form* is used in athletics to refer to perfection of function. Effective and complex function is as worthy of appreciation as is desirable or accepted shape, once the effectiveness and complexity are meaningfully perceived. It is because insight into the significance of function has come so late in history that untutored emphasis still tends to rest

on form. The replacement of anatomy by physiology indicates a comparable change at the technical level, but too often this change has not been accompanied by help toward conscious appreciation of the beauty of function, so adolescents have felt something was being taken from them that they enjoyed, even though partly illicitly. Appreciation of this sort, in connection with the functioning of the human body, is of course only a special case of the larger conception of fitness and efficiency discussed above.

The place of tradition in appreciation is an important one but it has probably been overemphasized. Traditions do, quite properly, set standards, but it is an inadequate view both of beauty and of tradition which holds that the beautiful is determined solely by the standards of others or by the standards of a few late Renaissance painters. The adding of new elements to our tradition is one of the primary objectives of many art teachers; this can also be done in biology, hygiene, and physical-health courses.

Beauty in the laboratory surroundings is a comparatively undeveloped field. The old-fashioned laboratory, with its fumed oak furnishings, stuffed oriole, dusty pine cone, and bad lithograph of Charles Darwin, develops associations with science that are antithetical to most of the appreciations under discussion. Light rooms, living exhibits, anatomical preparations made by students, murals with science subject-matter, are becoming more common, and they facilitate appreciations of the sort to be valued.

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IV

MEETING THE NEEDS OF ADOLESCENTS IN IMMEDIATE PERSONAL-SOCIAL RELATIONSHIPS

INTRODUCTION

The Scope of Needs in This Aspect of Living

Though every person's effectiveness and happiness depend to a large extent on his success in personal-social relationships, these relationships are of particular importance to the adolescent. The transition from childhood to adulthood forces upon him a wide variety of new and constantly changing adjustments to other people, and a large fraction of his time and energy is absorbed in working them out. If this does not hold true in any given case, it is probably because the young person is having such great difficulty with his personal adjustments that he gets little satisfaction from them and is forced to seek it elsewhere. But these adjustments are normally matters of absorbing interest and often, likewise, occasions for considerable perplexity.

The contemporary adolescent's task of achieving maturity in immediate personal-social relationships is complicated by the fact that he lives in a changing society. There are few ready-made patterns for him to take over and make his own. He must find his way in the midst of a welter of conflicting ideals and standards, since the older generation, upon whom he could presumably rely for help, is itself confused. His parents and their contemporaries have never been obliged to contend with a problem like his, for they have grown up in a time marked by far greater harmony among the demands which relationships with others make upon the individual.

The adolescent's experiences and emotions in working out

personal-social adjustments are of various types and intensities, running the gamut from jubilant exhilaration or quieter satisfactions to tempestuous conflicts or black loneliness. In his attempts to cope with his own new feelings and impulses, to understand other people and to develop skill in his relationships with them, he sometimes finds the sailing smooth and at other times is baffled and perplexed, at odds with others or with himself. He is often assailed by doubts, fears, and misgivings concerning his ability to grow up. He suffers because he feels that he cannot make his actions and impulses consistent with his ideals or with the demands of others. He is confused, unsure, unsuccessful in handling his relationships with people.

This is not to say that adolescence is necessarily a tragic period of life. Ordinarily the burdens of adolescent development are easily and buoyantly carried. The adolescent can work out some of his problems for himself; for others he can find ready guidance; but many remain, and there is much that he cannot or will not talk about on his own initiative. At many points help from understanding older persons may make the difference between an unsatisfactory or only partially satisfactory adjustment and a very adequate one. Such help may serve not only to straighten out present difficulties but also to aid in smoothing the path for later, more mature adjustments.

Of the many personal adjustments with which he has to cope, those within the family are usually of primary concern to himself. Further, the patterns of relationship that he works out within the family are likely to continue to affect his relationships with age mates and adults outside the family. His behavior is characteristically ambivalent and unpredictable: toward his parents he exhibits a somewhat bewildering but exceedingly significant mixture of dependence and independence, and his relationships with other adults are similarly vacillating, though to a somewhat lesser degree. His attitude toward his teacher, for example, may shift from friendliness to aversion and back again with great rapidity and for no ap-

parent reason. He is likewise deeply absorbed in working out his relationships with age mates of his own and the opposite sex. The patterns of these relationships change rapidly as he passes from one level of development to another.[1]

The needs of the adolescent in his immediate personal-social life may then be summarized under two broad headings:

1. THE NEED FOR INCREASINGLY MATURE RELATIONSHIPS IN HOME AND FAMILY LIFE, AND WITH ADULTS OUTSIDE THE FAMILY
2. THE NEED FOR SUCCESSFUL AND INCREASINGLY MATURE RELATIONSHIPS WITH AGE MATES OF BOTH SEXES

Inasmuch as personal relationships within the family involve some rudimentary understanding of the family as a social-civic institution and some knowledge of the way in which the application of scientific discoveries has affected the rôles of family members, it is necessary here to encroach to some extent upon material which is primarily a part of Chapter V on "Social-Civic Relationships." And because increasingly mature relationships with age mates, particularly of the opposite sex, so intimately involve increasingly mature sex attitudes, a final section of this chapter is devoted to a discussion of sex education in some of its more general aspects.

These two needs are of course not mutually exclusive. As earlier indicated, successful relationships outside the family derive in large measure from successful relationships within it—attitudes toward parents are likely to color attitudes toward other adults outside the family, and those toward parents and siblings to have a profound effect upon attitudes toward age mates of both sexes. Understanding oneself and developing constructive attitudes toward oneself are also essential elements in establishing successful relationships with others.[2]

[1] See Chapter VIII.

[2] This need has already been discussed in Chapter III (in the section on "Personal Health" and more particularly in the section on "Self-Assurance"). Chapter VIII on "Understanding the Student" discusses the adolescent in greater detail and includes case-study material of particular interest to the science teacher.

Development of Desirable Characteristics of Personality

It is clear that any real satisfaction of the needs outlined above requires also the development of the desirable characteristics of personality described as important educational objectives in Chapter II. For example, the adolescent must be helped in applying reflective thinking to his personal-social problems. Part of his more mature adjustment in immediate personal-social relationships depends upon intelligent self-direction in his personal affairs, and upon social sensitivity, coöperativeness, and tolerance. Only by the development of these qualities can a foundation be laid for mature adjustments either in these relationships or in the broader relationships of social-civic and economic life.

The Task of the Science Teacher

What then can the science teacher do to aid the adolescent in meeting the needs outlined above? As we see it, he can serve in two capacities: first, that of the approachable, understanding, respected, and well-balanced adult, and second, that of the teacher who makes definite contributions from the field of science. In this area—personal-social relationships—even more urgently than in any other, the first of these rôles is prerequisite to the second. The adolescent can make only limited use of intellectual concepts in most of his personal-social relationships, and he can apply these only in so far as they are accompanied by constructive attitudes. No adult except the kind described above can help him develop these attitudes, and the teacher who would guide the student successfully in the fine art of living must have skill and experience in that art himself.

As far as specific science content is concerned, this will include such factual information as will aid the adolescent to a functioning understanding of his relationships in the family and with adults and age mates of both sexes and will help him develop a philosophy of life in dealing with the people around

him. Much of this material at present lies in an educational no-man's land: responsibility for some of it, surely, should be in the hands of the science teacher. Just exactly how great his contribution should be depends on the particular science teacher and on the situation as a whole. But to achieve the finest results, the science teacher must orchestrate his efforts with those of teachers with similar objectives in other fields. Among these may be included teachers of literature, home economics, social studies, or the various creative activities, or recreation leaders—in so far as each of these is concerned with human relationships.

THE NEED FOR INCREASINGLY MATURE RELATIONSHIPS IN HOME AND FAMILY LIFE[3]

The Adolescent and His Family Relationships

The young person who finds himself in rebellion against his parents often imagines that his situation is peculiar. And so may his parents. Adolescence in contemporary society is likely to involve a good deal of misunderstanding, perplexity, and conflict within the family. This does not mean that the adolescent has stopped loving his parents, but it does mean that questions and situations frequently arise which the adolescent and his parents interpret and act upon in quite different ways. For example, many of the means that adolescents employ in order to establish themselves with their age mates, such as driving automobiles and seeing moving pictures, seem quite legitimate to the young person, but to the parent who did not do these particular things in his own youth they often seem precocious, extravagant, dangerous, and immoral. That

[3] No attempt has been made here to deal fully or adequately with the question of the adolescent's relationships with adults outside the family. As already noted, these relationships are profoundly influenced by the adolescent's relationships with his parents. This is the period of weaning from home, and the effects of this weaning process on the student's relationships with teachers and other adults—whom he substitutes for his parents, sometimes as advisers and sometimes as models—are noted at various points throughout.

one generation should misunderstand another is not new in history, but the gap between generations is wider under the conditions of present-day society. Hence it is correspondingly harder to bridge.

It seems reasonable to suppose that in many cases this conflict between the generations would at least be eased if the adolescent could gain some insight into why he feels and acts as he does, why his parents behave as they do, and how the situation comes to be as it is. Helping him (and perhaps also his parents) in achieving this insight and objectification of problems is one of the contributions which the science teacher may well make. Understandings related to the following generalizations are held to be pertinent:

1. The transition from childhood to adulthood necessitates a rapid sequence of new adjustments and rôles for the parents and for the adolescent.
2. In contemporary society individuals reach sexual maturity earlier than they reach economic, social, or even emotional maturity; this may produce important conflicts at the time of adolescence.
3. The older generation is having difficulty in its own present adjustments.
4. The experiences the older generation had in its youth were different from those which the modern adolescent is now having; hence the gap between the generations is wider than in more static societies.
5. Parents have lost much of their former vested authority in controlling the adolescent, who consequently must make many more decisions for himself.
6. The patterns of what the adolescent may do as an adolescent and what he is expected to grow toward as an adult are not crystallized in modern society, since current mores are in a state of flux.

Some large part of the problem of family adjustment with which the adolescent is confronted derives from the fact that the family as an institution is itself in a period of change both as to its functions as a unit and as to the rôles of its members.

The fact that home and family life is very different from that of a century ago or even a generation ago is due largely to the development of the sciences. As a result of scientific invention the home has lost much of its specific economic function as a self-contained unit. Almost all productive economic activity is now carried on outside the home. Similarly, education of the young, both secular and religious, has been taken over largely by community agencies. Even much of the family's recreation is provided commercially or by other agencies outside the home. These conditions apply most fully in urban families; increasingly they apply to the rural family as well.

The loss of functions once performed in the home has resulted in shifts in the rôles of the various members of the family. The rôle of the girl and the woman in particular has been modified, so that the position of woman in modern society is changing and uncertain. Her release from many former household activities has resulted in a new freedom, and the forms which this freedom should take inside and outside the home have not yet crystallized into generally accepted patterns. Hence neither men nor women, young people nor adults, know quite what is expected of them nor what to expect of one another, nor exactly how to make the best adjustments for the welfare of all concerned. There are, however, two important functions of the modern family which no other agency can perform so well, namely, affection-giving and status-giving.

Generalizations

The following generalizations summarize the situation fully enough to make further discussion unnecessary at this point. The teacher is in best position to decide in what ways and to what extent these generalizations represent understandings desirable for his particular students:

1. Scientific discoveries and inventions have had important effects upon the constitution and functions of the family.

a. The number of persons in the modern family-household is decreasing.
   (1) Urban families have fewer children; maiden aunts no longer make their home with married sisters; and though the number of old people is increasing, they tend less and less to live with their married children.
   (2) Contraception, economic factors, and the changing position of women are basic to these changes in family size and composition.

b. The number of functions performed by the family unit is decreasing.
   (1) Almost all productive economic activities are now carried on outside the home.
   (2) As the school has taken over the function of educating the young, so other community agencies have taken over a large share of the responsibility formerly carried by the home in giving religious instruction, caring for the health of family members, and providing for the handicapped.
   (3) Recreation is likewise no longer primarily a family function; it is now provided either commercially or by community agencies.

c. As far as is now foreseen, nothing can replace the family in its affection-giving and status-giving functions.

2. The applications of the sciences have had important effects upon family relationships and family member rôles.

a. The position of women in modern society is changing and uncertain.
   (1) A woman may now choose as to whether she will marry or not marry, be a mother or remain childless, engage in or refrain from economic activities outside the home, etc.
   (2) This new freedom implies the possibility of abandoning the traditional feminine rôle, but its recency has not yet permitted universally accepted new patterns to emerge; hence no one is sure what a woman should be like, what kinds of conduct are proper and desirable for her, in what kinds of activities she may engage, etc.
   (3) Since, in consequence, men are uncertain of what to expect of women and what responsibilities are properly

women's, they are themselves uncertain as to the extent and limits of their own rôles as men and are unsure in their approach to and relationships with women.

b. Much of the time and energy of the mother has been released from the activities to which they were previously devoted, and she is now relatively free to concentrate upon the care and guidance of children and the cultivation of improved family relationships.

(1) The release of the mother's time and energy is due to the reduction in the number of children she bears and rears; the removal of productive activities from the home; and the lightening of the burden of housekeeping through mechanical aids, newer architecture, modern furnishings.

(2) The mother's concentration upon her children and upon relationships in the family may constitute an opportunity for more intelligent child care and higher levels of human relationship in the family, or it may degenerate into unhealthy oversolicitude and destructive introspection.

c. In general it may be said that fewer and fewer common family activities of necessity now carry the whole weight of the affectional relationship in the home, and the home must therefore be carefully conducted in view of the possible strains and potentialities inherent in this situation.

d. Parental authority is declining as a method of family control.

(1) This decline in parental authority is an aspect of the more general decline of authoritarianism which has resulted from the widespread dissemination of the scientific and democratic point of view, which holds that it is legitimate to question any authority.

e. Changes in patterns of human conduct derive from a number of sources, all of which may be related to some factors in scientific invention and the scientific age to which it has given rise. (Changes in the patterns of courtship, for example, derive from the introduction of the automobile, the decline in parental authority, and the changing position of women and girls.)

f. Improved living conditions (due to improved transportation,

sanitation, communication, and housing) provide the necessary physical conditions for the improvement of human relationships in the family.

g. The family remains prepotent in the formation of the attitudes and feelings with which the individual approaches persons and situations throughout life.

To the adolescent the family situation outlined in the above generalizations presents not only difficulties of adjustment but opportunities unusual in the history of the race. The fluidity of the culture and the release of human energy through inventions and power-driven machinery set the young person free to contrive new patterns more compatible with fundamental human desires.

If the adolescent becomes familiar with the external factors that shape the modern family situation and with the biological and psychological data that explain his behavior and feelings in relation to those of his parents, of what actual value is this insight to him? To grasp facts intellectually by no means automatically assures emotional acceptance of the information nor adjustment in terms of it. To understand the source of a difficulty does not abolish the difficulty. Nevertheless, insight into the situation summarized in the previous generalizations may produce some constructive results.

For example, if the adolescent understands why his parents behave as they do and appreciates the present difficulties of parents both as people and as parents, he is at least more likely to have increased sympathy for them and to approach them with less misunderstanding and irritation. This objectification of the problems of the family paves the way for increased tolerance, coöperativeness, and social sensitivity in family relationships, although such change does not follow automatically upon the acquisition of information. Study of the family from the point of view of changes wrought through the impact of scientific invention and thought provides the young person with a context that tends in general to objectify his problems and give them perspective in time and place. And through

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this type of objectification it is possible to impress the student with the fact that the very confusion of present-day society, caused as it is by the freeing of human time and energy, presents opportunities for him to control life in terms of human needs to an extent unparalleled in the history of the world—and to do this at a stage in his development when he is most responsive to worthy causes.

Let it be understood that understanding is not offered as a panacea for the adolescent's difficulties in his family relationships; the results of such understanding can, however, be constructive. The additional results that might be achieved through parent education are worthy of investigation.

Types of Constructive Adolescent Participation in Home and Family Life

A large part of the adolescent's time should be spent in independent experiences, making friends among his age mates, learning to solve his own problems, taking his own risks, and facing the consequences of his own mistakes. It is not desirable therefore that a large part of his time should be spent in the modern home, unless the home presents a rich opportunity for such experiences. One of the things that the adolescent wants most from his family is the freedom to seek new friends and experiences outside the home.

Further, any form of family-centered activity which ties the adolescent emotionally to his parents at the very time when he should be breaking away from them cannot be regarded as constructive, for "escape" from the family refers primarily to emotional escape, only incidentally to physical escape. Through growing up, he should achieve a new and recognized status in the family. The right type of shared family activities —in which each member makes a characteristically different but important contribution—may help in this process. They should also help him to see his parents as persons and as friends, instead of as very old people who are remote from him

in personal interests. But they must not interfere with his emancipation from the home.

There are possibilities for both work and leisure-time activity in the home which are worthy of cultivation. The home is still the social unit; it retains its affection-giving and status-giving functions. It would help many parents to realize that the supreme thing adolescents desire of them is friendship and acceptance on a more adult level. This friendship and working membership in the family is fostered through shared activity, and this shared activity becomes undesirable only when it prevents the adolescent from establishing sufficient and appropriate contacts outside the home or achieving a more mature status within it.

If the adolescent is to profit from activity shared with his family in the home, this activity must be on an increasingly mature basis. It must provide for increasing degrees of self-direction by permitting the adolescent to assume more and more adult responsibilities; his opinions and his contribution to shared activity must be respected in their own right. A family which is a genuine democracy has a threefold value: it enhances real comradeship between parent and adolescent; it contributes to his basic security, his sense of belonging; and it gives him the kind of practice in responsibility which he must have to participate effectively in a democratic society. If this is the situation, there are many activities that the science teacher can help foster. A few of these are suggested below:

Leisure-Time Activities. Many of the personal interests suggested in Chapter III can become interests shared with one or more members of the family. The school can contribute here by helping students develop these interests and by suggesting to the parents themselves ways in which they can share interests with their children.

It appears to be a truism that "the family that plays together stays together." For some families camping, enhanced by first-hand shared study of flowers, trees, insects, animals, or rocks, provides a

happy vacation. Motor trips can be similarly enjoyed. For example, in a summer tour which one family took through the western states, each member of the family undertook to be an expert on one thing in which his knowledge would contribute to the family's pleasure. The fifteen-year-old boy was the family geologist.

In general, if the parents are bored by shared activities, the adolescent will sense this. It is better for the adolescent to become interested in the parent's hobby than for the parent to attempt to take up the adolescent's. Such homely pursuits as gardening, photography, and the study of birds, flowers, stars, and the like, constitute scientific hobbies which the young adult may enjoy with his own family and later with his own children, and which the science teacher can help foster in students who find them interesting.

Practical Competence in the Home

Despite the fact that productive economic work has been practically removed from the ordinary household, the physical operations involved in home maintenance are still important, and the adolescent's understanding of life is better rounded if he has some contact with manipulative and practical procedures. The physical operation of a household falls into the area in which the work of the science teacher overlaps that of the teacher of industrial arts and the teacher of home economics. Simple repairs—making electrical connections, repairing water faucets, replacing electrical fuses, painting, and varnishing—should be learned by both boys and girls. Care of children, first aid, home nursing, simple sewing, planning and preparation of meals are semi-scientific activities which, when rightly presented, are interesting to both boys and girls.

Household tasks are acceptable to the adolescent when they involve a gratifying assumption of responsibility, or a sense of achievement, or the respect and approbation of the family, or are truly felt to be part of a coöperative venture, or a service gladly rendered through affection. Under less happy circumstances they are merely drudgery. Since adolescents crave new experience, they should not be kept too long at the same tasks, but allowed to use a variety of skills and interests as these de-

velop. However, it is well known that adolescents will stick for hours at tasks which have meaning for them.

Preparation for Later Home-Making

Many activities interesting to the adolescent may serve as preparation for the time when he has become an adult with a home of his own. Some of his activities mentioned in the preceding sections are of this type—activities that facilitate the operation of his own home or provide leisure-time activities which he can share with his own children. Observation and care of children deserve some particular mention in this connection. Many older adolescents find this activity interesting and worth while; in some instances study of children has been utilized by teachers as a basis for health instruction, or for the study of human development and behavior.

It should be mentioned in passing that activities which are preparatory ventures appeal chiefly to older adolescents, but not to all older adolescents. Preparation for home-making is probably not often the most successful motive; instead it is usually a concomitant outcome, with intrinsic interest in the activity and the sense of achievement and mastery the more important immediate factors.

THE NEED FOR SUCCESSFUL AND INCREASINGLY MATURE RELATIONSHIPS WITH AGE MATES OF BOTH SEXES

Nothing is more important to the adolescent than making friends. A significant part of his happiness or unhappiness lies in the degree to which he receives the specific approval and liking of individuals and the general acceptance of the group. In early adolescence it is friendships with his own sex that are important to him; in middle and later adolescence the range of his friendships expands to include members of the opposite sex.

It is normal for adolescents to form strong attachments to

individual members of their own sex. These may be older persons—teachers, upperclassmen, etc.—or they may be age mates. Another common pattern of relationships at adolescence is found in the so-called clique. The school is frequently much concerned with breaking these down, on the assumption that they are unhealthy. Actually, the clique is more or less of a normal social arrangement at adolescence and should not occasion too great concern on the part of adults. On the other hand, artificial social barriers between members of different grades and rooms need badly to be broken down. Students of the same age and sex, who may be grouped together in the same grade, vary rather widely in the level of their social and physical maturation and should have more opportunities for friendship with others at their own level whether in their own class or not. Still more important is the factor introduced by earlier physical and social maturation of girls, who should be permitted and encouraged to have social contacts with boys one, two, and three grades ahead of them. The twelfth-grade girl has a special problem with which the school should make an effort to deal through other agencies in the community.

The science teacher, as science teacher, can probably make no unique contribution toward helping a student establish himself securely with his age mates. Every understanding teacher, however, does a great deal in helping the members of his class achieve successful relationships with one another, both in work and in play. He is in a key position to help the class leaders recognize and develop the talents of the other members of the class and draw them into the group. He can likewise help the poorly adjusted student to see the reasons for his difficulties and find ways of overcoming them. In the way in which he guides the various class activities, whether they are projects undertaken by small groups or extracurricular interests involving the whole class, the teacher is able not only to encourage the development of social sensitivity, tolerance, and coöperativeness, but also to help bring out the unique contributions of individual students in such way as

to secure for them approbation in the eyes of their classmates.

Such help will be given largely through informal activity of the teacher. Perhaps, however, there is, in addition, a place in the curriculum for the study of immediate human relationships as such. In addition to units or courses designed to help the adolescent understand himself, there might also be included (under the guidance of the science teacher or otherwise) opportunities for adolescents to learn why people react to one another as they do and what makes one's immediate social relationships successful.

The adolescent's relationships with members of the opposite sex are discussed at considerable length in the section on sex education which follows, for sex education is concerned not only with physiological processes but also with all the social and emotional relationships between the sexes.

SEX EDUCATION

The Scope of Sex Education

The rôle which sex plays in human living is many-sided and pervasive. The purely physical aspects of the reproductive process are a fundamental manifestation of sex, but for human beings they are only one of its important manifestations. Emotional and social factors of tremendous significance for individuals and for society are also involved. Various forms of human behavior, constructive and destructive, are associated with sex drives. Prostitution, homosexuality, and sublimations in the form of the arts and literature, dress, dancing, and movies, are examples of these.

Sex education is not just something that the parent, the biology teacher, or the religious instructor tells the child. Nor is it something that the child picks up in the alley or behind the barn. Nor is it what the moving pictures or the dancing class and other social activities convey. It is all of these things and far more. Sex education is a concomitant of living, and to an increasing degree it has become apparent that the success

or failure of the individual to attain those relationships described earlier in this chapter is to a large degree dependent upon the nature of his sex education.

What is the school's responsibility for the sex education of the adolescent? What should constitute sex education for younger and older adolescents, and what is the rôle of the science teacher in connection? These three questions, particularly the last one, are the concern of this section. Though no one can answer these questions with sureness and completeness—sex education is an area in which much skilful, detailed, and courageous research is needed—this section explores relevant considerations and suggests a point of view and certain consonant procedures.

The School's Responsibility for Sex Education

Obviously, sex education is somebody's responsibility. In spite of overwhelming evidence to the contrary there is widespread feeling among many adults—parents, teachers, and others—that sex is a topic better let alone; they fear possible damage to the child if the subject is poorly handled. This fear is needlessly great in view of the actual situation. Without consciously realizing it, these adults tend to assume that so long as they avoid the task, the child or adolescent learns nothing about sex. But actually, despite wishful thinking to the contrary, it is of course impossible that the child or adolescent remain a blank page on the score of sex information or, even more particularly, sex attitudes. If legitimate sources of accurate information and desirable attitudes are cut off, he either broods over his questions secretly or resorts to whatever the "grapevine of the gutter" has to offer. The choice is not that of whether he shall or shall not receive sex education; it lies between helping the youngster and letting him rely solely on his own resources.

It is an open question whether the sex education of young people lies primarily at the door of parents or teachers. Many

people feel that sex education is the parents' job, and only the parents' job. Certainly there are things which the parent can do better than any other agency by virtue of his position as parent, provided he is factually and emotionally equipped to do so. But even many of those who believe that parents should have the main responsibility confess that the great majority have not accepted this responsibility or have not been able to meet it with any degree of adequacy. This holds true even in many cases where parents most resent intrusion. Others are very anxious for the school to take the whole responsibility, and indeed there do seem to be some aspects of sex education which the school can usually handle more effectively than can the parent.

However, the whole problem needs to be worked out thoughtfully and coöperatively by all concerned. At the present time it would seem that the most satisfactory solution is a sharing of the responsibility by both school and parents, assisted by the church and other similar agencies. This section proceeds on the assumption that whatever the school can do well becomes the school's job unless it is being done better elsewhere.

Since, then, the school is properly called upon to take over the responsibility of sex education on a partnership basis with the parents, and since most parents are unequal to the task, it would seem that the school has a dual responsibility. First, it must help the parent to do a better job of sex education in the home, and second, it must help the child in ways that his home is at present unable to do. Helping parents to meet their children's needs in regard to sex education is a responsibility which the school of the future should assume, perhaps in cooperation with other agencies. Although the school's opportunities and responsibilities in this connection cannot be discussed here, it is obvious that parent education is vitally important to successful sex education in both home and school.

Further, there should be close coöperation and sympathy

between parent and school in regard to the school's program for sex education. Many schools, for example, find it desirable to inform the parents, preferably in a personal meeting with the teachers most concerned, of the school's program in regard to sex education and the part it plays in the total school program. Such information should be given parents at the start of the school year and not just before the first specific sex education begins.

But how should the school proceed to meet the second of its responsibilities in this connection, namely, providing sex education for the child? Sex is a part of life, and it cannot be treated out of context without suffering from that isolation. The materials pertaining to sex education probably will be presented in better perspective as part of courses larger in scope and objective—and not labeled "sex education." Such courses as biology and English, and other courses centering around important human interests, serve as appropriate vehicles. And no one year can possibly suffice. At each level of development the individual has new needs and interests. Some aspects of sex, ultimately essential, will not be grasped until adolescence even though they be presented earlier.

The best plan, then, seems to be continuous sex education, throughout the child's school life. Materials coming from various subject fields, and scaled to meet different needs at different ages, should form an integral part of courses or units of broader scope and should be taught by teachers well equipped through personality and training—and through knowing the same students from other contacts.

The personality of the teacher who deals with sex problems is even more important than is his factual knowledge. He should have faced sex frankly and should be normally interested in sex as it concerns him personally. It is obviously most undesirable for teachers who are afraid of the topic—or too interested in it—to discuss sex with students, thus compensating vicariously for their own emotional privations. The teacher should be responsive, sympathetic, but not sentimental, and

should be sufficiently sensitive to understand and respect the feelings of his pupils.

Many teachers are themselves products of an education that did not take into account sex education in the sense in which it is discussed in this report. They therefore find it necessary to supplement their own education along these lines, though little has been done in in-service training in this field and little of value has been written for the teacher. Through contacts with psychiatrists, psychologists, social workers, and other teachers who have taken a particular interest in these problems, the teacher can seek to improve his own equipment. Increasing interest in the problem of sex education on the part of teachers will create a demand for better sex education in teacher-training institutions. Certainly every teacher in training, regardless of his major subject, should be given instruction in sex education and in the point of view suggested by the discussion in this chapter.

Sex Education for Younger Adolescents [4]

It has already been noted that sex education properly continues throughout life; therefore it is desirable to review briefly the nature of sex education appropriate to the years just prior to adolescence before approaching this question.

Before the child reaches puberty, he should have acquired specific factual information which may be enlarged upon during early adolescence. The following minima are suggested: an acquaintance with mechanisms of reproduction in animals and plants; an understanding of normal human sex physiology and the anatomy of both sexes, and of appropriate personal hygiene; and a vocabulary of anatomical, physiological, and social terms adequate for frank discussion of sex problems.

It is immediately obvious that the real place to begin this

[4] In this discussion, *pre-adolescence* corresponds roughly to elementary-school age, *early adolescence* ("the younger adolescent") to junior high-school age, and *later adolescence* ("the older adolescent") to senior high-school and junior-college age. It should also be noted that boys mature a year or two later than girls.

work is in the home with the preschool child. The parents' rôle is vital, since lifelong attitudes are founded when the child is very young. As the child grows older, the well-oriented parent can be his most valuable counselor. The teacher, however, has a special responsibility in the present state of sex education, for he must often attempt to make amends for earlier omissions or mistakes.

The major contribution which the teacher in elementary school can make to the sex education of his pre-adolescent students is to help them develop constructive personal attitudes toward body processes, reproduction, and other physical aspects of sex. The achievement of such attitudes involves the avoidance of certain destructive reactions (or their eradication if they have already been acquired).

Such reactions are those of shame and disgust at the thought of the sex organs and the physical side of sex behavior, together with the obverse of this, a manifestation of excessive curiosity concerning these. Associated with these two is the reaction of fear for one's normality, usually founded upon the practice of masturbation and the reaction of adults to it. If the fear is great enough it can act as a force inhibiting frank discussion of any sex problems. Thus a pupil is filled with distaste for all aspects of the subject and fears that he will lower himself in the opinion of others by confessing his thoughts and practices. The pupil who has inhibited all conscious thought of sex because of the negative attitude of parents or others will fear to discuss sex because he thinks it is "wrong," or because he lacks words to say what he wishes, or because he fears the ridicule of more experienced persons. Still another destructive reaction is a kind of bravado about sex which frequently leads to an injection of sexual topics when time, place, and audience are inappropriate.

Considerably before puberty, at the end of the latency period, there is a great interest in "how things work" without the personal emotional involvement and self-consciousness that come with adolescence, and this is the time when the

factual outlines of human reproduction should be presented by the elementary-school teacher with vocabulary appropriate to later use. Skilfully presented at this time such information answers present questions, paves the way for understanding of the changes which take place in the body during puberty, and helps establish the sort of constructive attitude which is so important a foundation factor in successful heterosexual adjustments later.

It is scarcely necessary to add that all pupils cannot acquire this information and these attitudes at the same age since different children of the same age have different backgrounds and are at different levels of maturity. Furthermore, discussion and presentation of factual material in class alone will not remove difficulties in all cases. Painstaking individual guidance, often by a trained guidance expert, is required where the source of the undesirable reaction is deep-seated and goes back to some kind of traumatic experience in childhood.

The reader is no doubt aware by this time that it is not possible to draw any sharp line of demarcation between what must be taught before puberty and what after. Neither is it possible sharply to distinguish between sex education appropriate for younger adolescents and that appropriate for older adolescents. However, some general considerations in relation to each of these developmental levels will prove useful if they are not too rigidly interpreted.

For the younger adolescent, as for the pre-adolescent, the physiological facts of human reproduction are usually sufficient, although it would be misleading and unfortunate if he did not become at least intellectually aware—he may not be capable yet of more genuine awareness—that for human living intimate relationships have great emotional significance. The younger adolescent is not yet concerned with establishing social relationships which differentiate between the sexes (except negatively, by aversion to the opposite sex, as during the gang stage). As stated above, this is the time when the student should be developing constructive attitudes toward his body

and its processes and toward the whole physiology and anatomy of reproduction and sex.

Although the techniques and methods of sex education must be worked out individually by each teacher, experience has proved the value of certain characteristics of good practice in relation to the development of desirable attitudes:

Emphasis should be always on the normal aspects of sex.

Questions which represent issues real to the group should be discussed frankly. A direct question demands an equally direct response.

When the adolescent has already formulated his question in terms of himself or of the human situation, it is usually wiser not to detour at this late date via the frogs and flowers.

The wide variation in background and maturity of individuals in a given group may make group discussion inadvisable for problems which are of concern to some members only. The teacher should make himself easily available for the discussion of such problems outside of class.

A cold and ruthlessly matter-of-fact teaching attitude in sex education is as undesirable as is sentimentality. In discussing sex problems or presenting factual information about human sex anatomy and physiology, the teacher should not go any farther than he can without self-consciousness. Otherwise the effort to develop desirable sex attitudes will be automatically defeated. The reaction of students, adolescents particularly, to overfrankness in the adult is either withdrawal, due to resentment at intrusion upon their privacy, or else a corresponding overfrankness which is emotionally undesirable.

Even if the child seems to be entirely lacking in sex information, it is important for the teacher to recognize that he is not a blank page, but comes to school with his own theories about all aspects of sex—theories which he may not be able to express in words or to tell adults, but which nevertheless profoundly affect the way in which he receives new and more accurate sex information. Though he may understand what the teacher tells him intellectually, he cannot accept it emotionally until the emotional problems responsible for his earlier theories have been resolved.

The science teacher will find opportunities for sex instruction in connection with such activities as the study of human physiology (including all body processes), study of animal life (including social life and life cycles), and study of plant and animal forms ranging from the simple to the complex.

Understandings of the type which result from this study are represented by the generalizations following. Full understanding of these generalizations will not be acquired all at once or at any particular age. The elementary-school child should have had experiences which develop rudimentary understandings of these generalizations in their simpler aspects. Building on this nucleus of experience, the student will acquire a fuller understanding in junior high school and a still fuller one in senior high school.

Generalizations

1. Reproduction is a universal and natural process in the biological world. All life comes from life.
   a. Germ plasm is carried, as far as is known, from one generation to the next.
   b. Reproduction is fundamentally the separating off of part of an organism to make another like itself.
      (1) Plants and animals possess a great variety of adaptations which aid in the reproductive process.
   c. Some plants and animals employ sexual methods of reproduction, some asexual, and some both.
   d. Sexual reproduction involves fertilization which is the union of two gametes, an ovum and a sperm, to form a fertilized egg or zygote.
      (1) The ovum usually contains some amount of food for the embryo.
      (2) Sexual reproduction may occur in all but the lowest plants and animals as well as among the higher.
      (3) Fertilization in higher plants results in formation of seed and fruit.
   e. The same biological pattern of sexual reproduction is characteristic of the higher mammals and of humans. (Detailed knowledge is here required.)

2. Development from zygote to complex organism proceeds in regular and definite fashion, very similar in all animals.
   a. Most complex organisms, including humans, begin life as a single cell.
   b. Earlier stages in the growth of animals are similar, and the higher animals during the course of their embryonic life pass through many conditions very similar to those of more primitive types of adult organisms.
   c. In general, the higher the organism the longer the period of development and the more parental care.
      (1) Survival of a species is accomplished differently by different species: some produce a few offspring and care for them carefully; others safeguard their offspring less but produce so many that some survive.
      (2) Before birth the mammalian embryo is in close physiological relationship with the mother.
3. Ovaries and testes produce hormones as well as organs for producing sex cells.
4. Human sex physiology has certain specific characteristics, although it is fundamentally like that of higher mammals. (It is not enough for the student to understand the reproduction of a type mammal such as the rat. Such knowledge rarely transfers to the human situation. The students must have specific information on human physiology.)
5. The physical side of human relationships, especially sex, is not something to be ashamed of, but is a vital, integral part of life.

Suggestions for specific activities are listed below. This list includes demonstration experiments, laboratory and other projects, topics for reading, class discussion, and reports, films, trips. It is not intended to be exhaustive, but merely helpful and suggestive. No sequence of experiences is indicated. The list is simply "source material" from which the individual teacher can select what is suitable to her particular teaching situation and organize it accordingly. Reproduction in mammals and humans is placed first for emphasis, but in actual classroom work most teachers prefer to build understanding of human reproduction on a broad foundation of acquaint-

ance with the modes of reproduction, sexual and asexual, of a variety of animals and plants. In the following lists those activities that are especially useful in elementary schools and the first years of junior high school are *starred.* This does not exclude them from use in grades nine to twelve. Though older adolescents should already be in possession of the understandings to be derived from these activities, it is of course true that many middle and older adolescents will not have developed acceptable understandings in this area and will have to be helped to do so. There is no hard and fast line to be drawn, for the unstarred items frequently have simple aspects and so may be adopted by teachers familiar with the material for use in lower grades.

Suggestions to the Teacher

1. *Reproduction of Mammals with Emphasis on Human Reproduction*

* Breed rats, mice, guinea pigs, dogs, cats, and other mammals. (Guinea pigs are especially satisfactory because they are born with fur on, eyes open, and able to run about.)

* Have reports, discussions, and demonstrations on comparative embryology.

Demonstrate animal foetuses (human foetuses may be seen in a museum, but it is usually emotionally upsetting, especially for girls, when they are brought into the classroom).

Discuss implications of embryology for theory of evolution.

Have reports and discussions on care and protection of young.

* Discuss human reproduction in detail from physiological point of view: organs of both sexes, normal reproductive process, embryonic development, physiological processes such as menstruation.

See films on mammalian and human reproduction (especially those utilizing animated diagrams).

Discuss rational sex hygiene, physical and mental, etc.

Discuss adolescent problems: for example, acquiring an effective personality, making adjustments to parents, etc.

Examine common superstitions about sex and sexual functions.

Discuss reliable sources of information.

Read selected references on physiology.

2. *Reproduction and Growth among Higher Animals and Plants*

* Breed pets such as rats, mice, snakes, fish (including guppies), dogs, cats, birds, frogs, etc.

* Hatch and study in laboratory the development of frog, salamander, toad eggs.

Make charts or reports on life cycles of frog, toad, salamander, etc.

* Make plasticine models of cleavage stages.

* Incubate chicken or duck eggs, opening and studying at each stage of development.

Dissect various animals.

* Study social life and life cycles of various insects, for example, ants, bees, moths.

* Examine and dissect blossoms of beans and peas to show reproduction in seed plant.

* Make pocket gardens with blotting paper between glass plates, using bird seed, lima beans, etc.

* Germinate various seeds.

Make posters showing various forms of reproduction in plants and their life cycles.

Discuss and report on interesting methods of pollination.

Have reports of outside reading on plant or animal forms not studied in class.

* See films on reproduction of frog, salmon, flowers, etc.

Make lantern slides to illustrate any point in the study of reproduction.

3. *Simplest Forms of Reproduction*

* Examine budding yeast in sugar solution.

* Study living amoebae, paramecia, etc.

Make or examine slides of amoeba and paramecium, etc.

Make photomicrographs of fission and budding.

* Expose agar plates to catch bacteria from air, fingers, coins, etc.

Make bacteria cultures (broths, smears, stabs, plates); examine bacteria under the microscope.

* Carry on experiments on spontaneous generation, for example, with broth or hay infusions.

* Use black bread mold to show spores.

* Grow mold "gardens" on bread or moistened crackers in Petri dishes.

Collect fern spores and grow them on moistened earthen brick.

Demonstrate grafting as a means of vegetative propagation.

* Experiment with regeneration in planaria.

* Experiment with regeneration from cuttings of begonia, cactus, etc.

See conjugation in paramecium and spirogyra.

Use ulothrix to show undifferentiated gametes.

Use oedegonium to show differentiation of gametes into ova and sperms.

Use vaucheria to show sexual reproduction among algae.

* See films on simple forms of reproduction.

Sex Education for Older Adolescents

Older adolescents are not concerned with the problem of reproduction so much as with the social and emotional aspects of their personal problems in heterosexual adjustment. This is the age when young people are striving to establish satisfactory relationships with age mates of the opposite sex, and their vestiges of concern with the problem of reproduction reflect a certain anxiety about their own normality and the reaction of other people to it. Sex has become to them a problem of social adjustment. They are in quest of a way of dealing with other people, particularly people of the opposite sex and with establishing a satisfying code of behavior in their relationships with them. Their needs lie in the area of the tactics and ethics of heterosexual adjustment, and it is with these needs that the science teacher is called upon to help them.

One aspect of the teacher's responsibility lies in discussion of factual information in class, whereas another lies in the

handling of students' emotional problems. Appropriate material for any given class may be suggested as a natural outgrowth of work in child care and development, or the discussion of personal problems (for example, the problem of developing an effective personality), or discussion of family, social, or racial problems.

It has already been pointed out that many different teachers should rightly be involved in sex education. This holds particularly true of the sex education of older adolescents. Recreation and extracurricular leaders have splendid opportunities for fostering the adolescent's skill in relationships with the members of the opposite sex (as well as with those of the same sex). Teachers of literature, of home economics, of social studies, may each make significant contributions to the adolescent's insight into problems of heterosexual adjustment. Probably the most constructive and most effective contributions at the present moment are being made by the English teacher in one school, by the health-education teacher in another, by the science teacher in a third—in short, wherever the best-equipped personalities are located.

Since emotional problems are implicit in all sex education at this level, the teacher must function always as a sympathetic, understanding adult with whom it is easy to discuss difficult questions and must be ready to supply pertinent factual information and to guide the adolescent to think out his own solutions. For distressing questions will be in the background of most student discussion in this area.

This holds true despite the fact that a few adolescents are "hard-boiled" and that there are pregnancies and abortions yearly among high-school students. The adult observer is often misled by surface behavior: the real purpose of those adolescents who display a great deal of bravado is to cover up their great uncertainty as to what it is all about. The adolescent is usually very much afraid of doing the wrong thing, and not at all sure what that is. Even those adolescents who are very little worried, and who do not find the establishing of

their new social relationships difficult, usually do have many questions on which they want help.[5]

Frequently the conscientious teacher shies away from discussion of these questions because he himself has no answer for them. Very often there is no one answer, no blanket recommendation that can be made. Social mores are in a state of flux; they vary from one time to another, from one place to another, from one group to another in the same community. Universally accepted patterns are lacking. The teacher himself is emotionally involved; sex problems are not remote from him or uncolored by his own experience. Despite these difficulties, he will be reassured as to his potential helpfulness if he but recalls that the adolescent faces the same confused picture,

[5] The following list indicates a few types of questions which have been frequently asked. The students' ages ranged from about fourteen to about seventeen.

GIRLS

What about petting? How far should one go? What do boys expect of a date? What time should we really be in at night? How long should you keep a date waiting? Should I go with the same boy all the time? Why do parents pry into our affairs, and suspect us of doing a lot of things we never do? Do you have to kiss a boy to have him like you? Why do boys get fresh? If a boy gets fresh, should I slap him or are there better ways? Do boys have anything like menstruation? What is normal menstruation? How can you get rid of a baby after it has begun? What is a Caesarean operation, and why is it necessary?

BOYS

How far should you go in necking? How do you get sexual diseases? What does a girl expect on a date? Will she go out with a boy who hasn't much money? Is masturbation bad? Do girls masturbate? Are girls gold-diggers? Just what do girls think? What do they want? Why does a girl's mother stick around? Why do parents always think you are going to do something you shouldn't? What should you do when a girl invites you in after the movies? Is it a good idea to go to a prostitute? What makes wet dreams?

BOTH SEXES

What is intercourse? What is it like? What about it? Is it all right? Is it all right if you use "safeties"? Is it all right if you love a person? If you are engaged? What about venereal disease? What about contraceptives? Does the Catholic Church oppose contraception? Why is it against the law to give specific contraceptive information? Is abortion the same thing? If a girl has an abortion, can she have another baby later? What is hermaphroditism?

and that for him it is further complicated by the newness of growing up. It seems reasonable, therefore, to hope that the adolescent is better able to make successful adjustments if he has the coöperation of the teacher than if he must make them alone.

But the teacher must refrain from moralizing. Because he is respected and admired by his students, he is usually pressed to give his answers; yet the adolescent will usually reject the adult's standards (together with the adult) if these standards diverge too markedly from his own. The teacher is usually more constructive and ultimately more effective if he is less direct in answering the adolescent and instead helps him to come to his own conclusions. One great service which the understanding adult can render the adolescent is in helping him to find the landmarks for choosing his own course. Nobody can tell him what is right, but an adult can help him to decide what things must be taken into account. He needs to recognize what authorities he is accepting.

Here is where the teacher's skill in asking leading questions enters. The student can be led to examine the extent to which the conduct he is discussing squares with his own ideals, and whether it is fair to parents, friends, or others for whom he cares. He must recognize the importance of the mores of the community and know that, although he has the right to—and perhaps should—disagree with them, he must also accept the risks that such behavior entails. He can also be encouraged to look at himself as he would look at some one else: "What do you think of others who are doing these things? Is it all right if another boy treats your sister the same way?" He will have to decide for himself.

The teacher's problem is further complicated by the fact that the students who confront him come of widely varying backgrounds and previous experience. They differ in temperament. They differ in the level of their development. While viewing his students when various types of questions are being asked, the teacher is keenly aware of the wide varia-

tions among them. As has already been stated, frequently the discussion necessary in answering one student's question adequately would be more than some other students would be psychologically and emotionally ready to use constructively. In such cases the teacher is justified in giving a relatively superficial answer in class and following the question up outside class with the individuals most concerned. The teacher must know when this procedure is indicated, must sense how far to go in a given situation and in what direction.

There is also the problem of "mixed classes." What topics is it desirable to discuss before boys and girls together, and what should be taken up only when the sexes are segregated? In the right kind of classroom atmosphere it is highly desirable to discuss sex physiology (such topics as embryonic development, the general aspects of menstruation, etc.) with boys and girls together, even as one discusses respiration and circulation. At the same time the teacher may indicate that there are associated problems which each sex may prefer to discuss alone. It would be worse than futile to expect to discuss the personal aspects of menstruation, for example, with a group of girls rendered painfully self-conscious and silent on their real problems and questions by the presence of boys in the room. The same holds true of many questions which boys would like to discuss, but which they cannot discuss in the presence of girls. On the other hand, boys and girls are much interested in what is expected of them by the other sex. Many problems of social behavior, ethics, and values profit by discussion in a group of boys and girls who are friends and have been classmates throughout earlier months of work.

Masturbation is a topic about which the adolescent is often afraid to ask, but on which he needs reassurance. It is often helpful for the teacher himself to raise the question in a casual tone in connection with some other topic under discussion. It is his responsibility not only to answer questions about masturbation but also to help the adolescent solve his problems about it.

Generally it is unwise for the teacher to say that masturbation is "all right." The adolescent who masturbates will not believe him anyway and will come to distrust him as a result. The main point to get across to the group is the universality of the desire. The fact is that probably all little children masturbate and that the urge to masturbate often becomes intense again during adolescence. Students of adolescence have noticed that the adolescent at times uses masturbation, the eating of sweets, and other childish satisfactions when he becomes overanxious about his present social adjustments. The intensity of his feeling in relation to friends of both his own and the opposite sex intensifies the problem. It is unwise for the teacher to explain these underlying reasons for masturbation at adolescence to the group. Rather he should relieve anxiety about the practice by indicating that it is not unusual and that it has none of the harmful results (such as ill health and insanity) indicated by earlier writers whose evidence was not scientific. The other step in relieving anxiety on this score involves helping the adolescent to work out his personal relationships with greater ease.

The teacher should understand that when masturbation is excessive, it is a symptom of deeper emotional instability. In such a case there are other symptoms, such as restlessness, lack of concentration, sleeplessness, and overanxiety. It is much wiser to refer the adolescent to a specialist on the basis of one of these other symptoms than on the basis of the excessive masturbation.

Current movies, plays, novels, and resultant comment increase the probability that the adolescent may become concerned about crushes and homosexuality. It should be made clear to him that attraction for members of one's own sex is common and normal at one level of maturation. This situation becomes a problem only when an individual is physically and chronologically an adult but has failed to develop psychologically beyond the homosexual stage.

Teachers should realize—though this is not for discussion

with students—that there are psychological problems causing such fixations. For instance, the child who is overdependent on the parent of the same sex tends to prolong the homosexual period. It is also true that the child who has been deprived of affection by the parent of his own sex frequently becomes involved in intense feelings for some member of his own sex in order to compensate for the earlier deprivation.

Petting is a fairly universal problem with adolescents. They ask: "Is it harmful?" "How far should we go?" There are no blanket answers to their questions, and teachers often dodge them for this reason. This treatment has led many adolescents to feel that adults fail them at the most serious crisis in their lives. It seems reasonable to expect teachers to face this problem squarely through admitting its existence and explaining that decisions must be made by the individual in terms of his own emotional make-up and the special physiological, psychological, and social considerations that confront him.

Without being obtrusive the teacher should indicate his willingness to talk over the problems of petting with each adolescent who cares to consult him. The attitude of the teacher at such conferences should be not that of an authority but of an older more experienced individual who is willing to help the young person think out loud and reach his own conclusions.

There are many questions which the adolescent will not ask in any class, even in writing. They "give him away too much." They are private problems, and he is unwilling to make them public. This may be due to fear of ridicule or of abnormality, or because some of his most treasured values are involved. Here it is tremendously important that the adolescent have opportunity to seek individual guidance from an adult whom he likes, respects, and finds approachable. If there are several people available instead of merely one, some students may find it easier to go to one, some to another, for help.

In personal conferences it sometimes helps the teacher to realize that the student who asks a question has a partial an-

swer already in mind. The teacher may encourage the student to express this partial answer and the basis for it, and his response will often supply the teacher with clues as to how to proceed. The teacher should also be prepared to have many questions presented in an indirect or disguised form.

Sometimes in these personal conferences the teacher feels that the services of a guidance expert are indicated. It is worthy of note in this connection that the introduction of a doctor or psychiatrist may serve to aggravate the student's anxiety when this anxiety involves fears of abnormality. In such cases the teacher who feels his own judgment or information inadequate might better consult the guidance specialist privately about the case instead of sending the adolescent directly to him.

Ideally guidance is the responsibility of all teachers. The fact that his chosen teacher will discuss his problems with him is of great significance for the adolescent. It must be borne in mind, however, that the specialist is still needed. It is one of the guidance responsibilities of the teacher to help the student understand the wisdom of consulting an expert when it is necessary. In other words, the teacher should help the student to see that the doctor does not merely cure but also aids in keeping well, that the psychiatrist or guidance worker likewise has the function of prevention and hygiene as well as the function of therapy.

In general what criteria should determine the way in which the teacher discusses problems with a given adolescent? Again, there is no blanket answer for the teacher. There are various considerations—the teacher himself, his training, his personal experience, the degree of his success in handling adolescents, the mores of the community. It is important that the teacher be fully aware of the *practical* standards of the community. These must be taken account of for the good of the student who must make his adjustments to that community and for the good of the teacher, who cannot diverge too far from the community mores if he is to exercise a constructive influence.

Then finally there are also the genuine needs of the particular adolescent. To see and to meet these the teacher verily needs wisdom, sensitivity, and courage.

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V

MEETING THE NEEDS OF ADOLESCENTS IN SOCIAL-CIVIC RELATIONSHIPS

INTRODUCTION

The Scope and Significance of Social-Civic Relationships

In defining the scope of social-civic relationships and their significance in the modern world, it is illuminating to distinguish between this aspect of living and immediate personal-social relationships, and to contrast the social-civic life of today with that of a century ago, when simpler social, economic, and political organization afforded better opportunities for effective and intelligent participation.

Immediate personal-social relationships are developed and carried on in face-to-face situations. They begin at birth and are essential to the processes of social maturation. A boy or girl becomes more mature in relations with age mates and adults outside the family through direct participation in family and other face-to-face groups which are essentially social in character, since activities in them involve genuine sharing in common interests and concerns. But though social education is a necessary and inevitable concomitant of living in close association with family and playmates, there is a break between these immediate personal-social relationships, on the one hand, and social-civic relationships, on the other, as schools, communities, and society in general are now organized. In a sense these latter relationships are *person-to-institution* relationships under modern conditions of life.

Neither civic institutions nor social organization now provide opportunities for direct participation in terms meaningful to the adolescent. The effective conduct of such relation-

ships depends in a large measure upon a conceptual grasp of the nature of social and civic institutions and their functions. A young person can cope with a problem in his family or in his circle of friends directly on a face-to-face basis; he cannot solve a social-civic problem in the same way. It is futile to assume first-hand responsibility for feeding and clothing the needy, for example; the social problem of poverty cannot be effectively dealt with on the basis of immediate person-to-person relationships. If such problems are to be solved, it must be through social-civic institutions, or even possibly through large social adjustments. But these are remote from the experience of the adolescent; too often he is unable to conceptualize the problem, and so he does nothing about it. The group with which he must work may be widely dispersed, and the issues at stake in achieving common purposes difficult to comprehend. Only by getting a grasp of generalizations and principles concerning social-civic relationships can he participate effectively in them—so remote and abstract have the effective elements in them become.

This difference between immediate personal-social and broad social-civic relationships is largely the result of the growing institutionalization and fragmentation of society that have come about with technological change and with increase in the size of population. A century ago most of the important social-civic affairs of the local community were conducted on the basis of immediate personal contacts. When illness visited the family "down the road" in those days, good neighbors went to their assistance; now public health services, hospitals, and health regulations stand between the helper and the helped. This institutionalization impersonalizes mutual helpfulness, cuts down the range of immediate personal relationships, and in some instances may even prohibit them as socially undesirable. Formerly each family that could afford it felt an obligation to aid some less fortunate family; now social agencies alone can deal effectively with the needy. Formerly each man was ready to drop his work at a moment's notice

in order to run to help put out the fire in his neighbor's house; now a full-time fire department safeguards the community far more efficiently than did the volunteer system. But for the citizen fire protection is no longer a personal concern, an immediately felt responsibility at the forefront of attention, calling for a specific kind of action. He pays for fire protection and depends upon it, but it is still remote from him.

In addition, the local community is notably less self-contained than it was a century ago. Society has become so interrelated that even public health, for example, is no longer a problem for mere local community attention: the local community may match funds with state and nation for the support of public health services; public health regulations are often state-wide; and the Federal health service coöperates with the national health agencies of other countries in the study and control of certain diseases. Formerly a man's political activities were centered largely in the local election and town meeting where the decisions most important to him were made; now his most important political action is the casting of an impersonal ballot for a remote candidate. The citizen is notoriously less concerned with local problems than with national issues. The Illinois farmer knows that his vote in the national election is of more importance for his prosperity than his vote in the township election. The individual's life is more and more affected by impersonal action taken with wide groups with whom face-to-face contact is impossible; the connections between immediate experience and the impersonal act of casting a vote or paying a social-security premium become more and more difficult to make, and there is a correlative tendency to shirk responsibility for collective action for the common good.

The same general trend is likewise apparent in vocational and economic life, for the economic and social aspects of living in modern society are inextricably interlaced. Chapter VI indicates the adolescent's needs in his economic relationships to be emotional assurance of progress toward adult status, vo-

cational orientation, the wise selection and use of goods and services, and effective action in the solution of basic economic problems. These needs all have social-civic import, because modern technology has so mechanized and fractionated industrial processes that the production, distribution, and consumption of goods require the coöperation of wide groups, geographically remote and personally unacquainted. The various operations that go into the making of a motor car or a pair of shoes are carried out in different places, and the anonymous output of mass production is shipped for use at the ends of the earth. This situation contrasts sharply with that which confronted the carriage-maker and shoemaker of a simpler day, when the social significance of vocational life was immediately apparent. Then they had no difficulty in seeing the social bearing of their labors, for they were responsible for all the operations that went into the construction of their products, and these products when completed were used in the local community by their neighbors and their friends. Today it is difficult for the workman to see the social significance of the small operation which he performs—the connections are remote, abstract, difficult to comprehend. In a real sense, he becomes a "lost individual" [1] until he becomes aware of the social bearings of his work. Like the Illinois farmer whose vote in a national election is of greater importance than in a local election, he too is closely associated in shared purpose with wide and distant groups with whom it is difficult for him to identify himself.

In view of this situation—the remoteness and abstraction of social and civic functions, and the helplessness of the individual in becoming aware of the social bearings of his own activities or in guiding them toward effective action with others with common purposes in the widely associated life of today—Lewis Mumford [2] urges

[1] See John Dewey, *Individualism, Old and New* (New York, Minton, Balch and Co., 1930), p. 53.

[2] Lewis Mumford, *The Culture of Cities* (New York, Harcourt, Brace and Co., 1938), pp. 382–383, 386. (Italics ours.)

. . . the restoration of the human scale in government, the multiplication of the units of autonomous service, the widening of the cooperative processes of government, the general reduction of the area of arbitrary compulsion, *the restoration of the processes of persuasion and rational agreement*. Political life, instead of being the monopoly of remote specialists, must become as constant a process in daily living as the housewife's visit to the grocer or the butcher, and more frequent than the man's visit to the barber. If the leisure that man has been promised by the machine counts for anything, it must count for the extension of the privileges of being an active political animal. For *every phase of group activity, industrial, professional, educational, has its political aspect: each activity raises special problems of power, organization, control, and discipline*. . . .

Once the human scale is overpassed, once the concrete fact disappears from view, knowledge becomes remote, abstract, and overwhelming; a lifetime's effort will not provide sufficient grasp of the environment. The more people who are thrust together in a limited area, without organic relationships, without a means of achieving an autonomous education or preserving autonomous political activities in their working and living relations, the more must they become subject to external routine and manipulation.

In so far as the remedy does lie in bringing political responsibility back to the local community, the school must follow, not lead. But the remedy must lie partly in extending the meaning of the term *community* for the citizen by extending his conceptual grasp of social-civic relationships. The general principles of society grow ever more powerful in the fate of the individual. He must come to comprehend them, for they encompass his life: with others he must gain some intelligent and responsible control over the phenomena to which they relate. And this constitutes a large measure of the task of general education in the area of social-civic relationships.

The Needs of the Adolescent in This Aspect of Living

The Committee proposes to define the needs of adolescents in this aspect of living as:

1. THE NEED FOR RESPONSIBLE PARTICIPATION IN SOCIALLY SIGNIFICANT ACTIVITIES
2. THE NEED FOR SOCIAL RECOGNITION

The personal-social character of needs has been discussed in Chapters I and II. It must be recognized that the need for effective participation in socially significant activities is to a large degree a social demand, not strongly felt by either adolescent or adult under modern conditions of life. Yet the welfare if not the salvation of democracy depends upon the creation of conditions that will stimulate the feeling of this need, not only among adolescents but among adults as well.

A hundred years ago the young person was inducted more easily and naturally into social-civic relationships than he is today, because these relationships then centered more closely in the local community than they now do, and he had first-hand, concrete experience in them. The difference was not so distinct between immediate personal-social and broad social-civic relationships. The local community was a laboratory of citizenship. Nowadays the young person neither shares in civic functions, nor does he normally and naturally come to know about them. The community and its concerns lie outside his ken. Older people are scarcely in a position to help him, because they too have lost the social bearings of their activities and their sense of immediate responsibility for group welfare in a society marked by a rapidly increasing interrelatedness, specialization of function, and institutionalization.

Yet in spite of the adolescent's insulation from social-civic life, it is not difficult to establish the fact that he does have a strong urge to participate in social activities. It has already been noted that immediate personal relationships in the family and with age mates begin the process which leads to social maturity; the adolescent is in a period of expanding social contacts and is beginning to seek satisfaction and significance in human relationships that reach beyond the immediate circle of his acquaintance. He cherishes recognition of his par-

ticipation in significant affairs as a symbol of adult status. That he enjoys working with others of his own age group for common ends is witnessed by the popularity of such organizations as the Boy Scouts, the Y.M.C.A., and the multitudinous clubs and other organized groups of the modern school. Membership in these organizations is in the main voluntary, and their activities are planned very largely by the young participants rather than by adults. Clearly, keen enjoyment is derived from a sense of "belonging," and belonging to a group engaged in carrying out common ends and purposes. The desire for shared responsibility for planning, executing, and evaluating socially significant activities is again demonstrated in some places by the appeal of youth movements.

The adolescent is not without felt desire for effective participation in socially significant activities, but he is blocked in its expression and development. As schools and communities are now organized, there is little opportunity for him to participate responsibly and meaningfully in social-civic affairs—even at his own level of school and local community life. The local community itself is less and less important in government and social life; the town meeting and the volunteer fire department no longer provide means for stimulating direct and responsible participation. And the school holds aloof from the institutionalized life of the area in which young people could gain the experience and develop the sensitivities and principles to guide them in their participations in the larger society. Until the life of the school and the community become better integrated, the personal aspect of needs in social-civic relationships is bound to remain undeveloped.

An attempt should therefore be made to help young people to find socially significant activities within the school and the local community which would make it possible for them to sense their social responsibility more fully and meaningfully. *Above all, what youth attempts by way of social responsibility must have weight in the eyes of their elders.* Older people must provide young people with opportunity to engage in the com-

mon life. Otherwise they prolong the period of social immaturity and irresponsibility to the detriment of youth and of society. These activities of the adolescent must, of course, be free from exploitation; they must be truly educative and lead to effective participation in the wider society. This calls for new forms of association which are just beginning to emerge as the school identifies itself more completely with the life of the local community.

But it calls for more. As indicated above, the full interrelatedness of modern social groupings cannot be immediately experienced. It extends far beyond the boundaries of any local area. Effective social participation demands understandings related to the structure and processes of modern society. Therefore the school must not stop at helping young people get a grasp of the social principles growing out of their immediate social experience in the institutional life of school and community; in addition it must help them gain such understandings of wider social-civic relationships as will enable them to extend the application of these social principles to their own wider social responsibilities.

The study of other societies, both those that are or have been stable, and those that are or have been broken down, confirms belief in the importance of urging the teacher to plan his program so that young people develop a zeal for responsible participation in socially significant activities, and the understandings requisite to make this participation effective under the conditions of modern social organization.

Consideration will now be given to the kind of experiences the school should provide for if it is to help youth to meet and develop the needs mentioned above and meet them in ways that are educationally effective. Because these two needs are so nearly the personal and social aspects of the same problem, the chapter diverges from the form of treatment employed in the other chapters. Instead of discussing each of the two needs separately, it analyzes first the situations in school

and local community through which the adolescent may gain first-hand insight into the meaning of social responsibility; second, it discusses the understandings that may make this insight effective in his wider social participation. In both instances attention is focused on the special rôle of the science teacher.

THE SCHOOL AND THE LOCAL COMMUNITY

The Advantages of Integrating School and Community Activities

The life of the school should be so organized and directed as to be an exemplification of democracy at its best, and as such it should of necessity call for increasing ability on the part of each to participate in managing common affairs. Growth in this ability comes only through practice; it is unrealistic to expect the young citizen at twenty-one to take over social responsibility when he has up to that time had no opportunity to learn to do so. But, on the contrary, throughout the period of adolescence the young person's opportunities for participation might be gradually extended from the school community to local affairs, and from there to the concerns of the wider community; and if this participation were accompanied by constant help in bringing greater insight to bear and in generalizing his experiences, there would be every reason to expect citizens to have a real sense of the meaning of responsible social participation through democratic processes.

It is, moreover, undesirable to separate participation in the life of the school from participation in the life of the community, for as the barriers between the two are broken down, the school utilizes increasingly its potentialities for reconstructing and refining community life.[3] Only under these

[3] For an interesting proposal for a community school see Samuel Everett and others, *A Challenge to Secondary Education* (New York, D. Appleton-Century Co., 1935), Chapter XIII, "Education as a Community Function," G. Robert Koopman; also Samuel Everett and others, *The Community School* (New York, D. Appleton-Century Co., 1938).

conditions is it possible to realize the ideal so eloquently expressed in the following statement: [4]

Children and youth, millions of them the world over, restless with tremendous energies! Communities, thousands of them from Pole to Pole, embracing the conditions and the materials from which we may create a far more ideal environment for better living! On the one hand, the great energy of youth requiring only a dynamic purpose to make that force the most constructive factor in social progress. On the other hand, cultures rich in potentialities, needing a great constructive force in order to realize the abundant human life which they are capable of providing. To coördinate these two mighty resources—to harness the energy of youth to the task of progressively improving conditions of community life—that is the supreme challenge to educational and social statesmanship.

Another advantage results from joining school and community processes. As the school participates progressively in community life, the compartmentalization of subjects now found in the conventional school tends to break down. It becomes increasingly impossible, for example, to deal with an actual social problem in terms of science teaching alone; on the contrary, the science teacher will of necessity tend to be closely associated with his colleagues in planning and carrying out educational activities. Thus in many of the illustrations given in succeeding sections of this chapter, the contributions of the science area are fused with those of other areas.

The utilization of community resources to give young people social experience permits the realization of other desirable ends. Stress was laid earlier on the need of the adolescent to extend his contacts beyond his immediate circle and to build the increased maturity which comes from meeting and learning to manage wider social situations. Breaking down the iso-

[4] Paul R. Hanna and others, *Youth Serves the Community,* a publication of the Progressive Education Association (New York, D. Appleton-Century Co., 1936), pp. 21–22.

lation of the student's school life from the life of the local community gives him opportunity to meet his need for social recognition and to grow at his own level in awareness of what is entailed in effective and responsible social participation.

Opportunities for Student Participation in Activities of Social-Civic Significance in School and Community

It is the responsibility of the school and the teacher to find opportunities for student participation of social significance, to stimulate the student's participation in them, and to help him increase his awareness of the social significance of what he does. Here effort is made to show how one type of common school activity may be used to these ends, suggest some types of participation in local community affairs and study of community problems, illustrate in some detail how one such project (in health) might be treated, and describe the values of the community survey in connection.

The science teacher may give his students experience in social participation not only through community activities, but to a certain extent in the school laboratories as well. The improvising and repairing of material equipment for the work of the school are of value not merely as preparation for later improvising and repairing of equipment at home or in the garage. Nor is it a modern version of the Squeers educational system, travestied by Dickens as a method of exploiting the helplessness of children and the ignorance of their parents. Such activities as the improvising, repairing, and eventually the constructing of more or less standardized equipment are educational not only in the field of science but in the field of social adjustment and coöperation as well. To secure the values inherent, however, the work must be carried on with definite awareness of its value to the school community and under the direction of teachers who understand what they are about.

In seeking to identify opportunities for student study of and participation in community affairs, the teacher needs to be

sensitive to the interrelationships between school activities and the activities of the community. There have been many instances of actual participation by students in projects concerned with community health and civic beauty.[5] Perhaps the most common starting point for such activities is the survey, in which the teacher takes initiative in developing a plan for studying the community with the help of pupils and local organizations; for example, in Flint, Michigan, the following program has been carried out: [6]

The unit on civic beauty includes a sketch of the growth of American communities, recent planning activities, zoning, building regulations, housing, transit facilities, parks, monuments, and so on. An inspection of a delinquency map at police headquarters is followed by an excursion to the neighborhood showing the highest incidence of crime. The federal housing program is analyzed and pictures of slum clearance projects are secured. A committee is appointed to discover what provisions the charter makes for city planning. Another committee makes a study of the width of streets and of the adequacy of traffic facilities. A program of public improvements is drawn up and presented for discussion accompanied by illustrations secured from magazines and other sources. The ninth grade pupils have interviewed the officials of many public agencies and they have reported their observations. . . .

An activity of this sort would probably best be carried out by a group of teachers representing various interests rather than by the science teacher alone. Thus the art teacher might be responsible for the esthetic aspects, the social-studies teacher for the distinctly social implications, whereas the science teacher would be mainly concerned with such elements as sanitation, disease, and other scientific aspects of crime prevention and slum clearance. (In this respect it illustrates the tendency referred to above, to cut across subject lines.)

[5] See Paul R. Hanna, *op. cit.*, for an account of many such instances.

[6] Henry Harap, *Progressive Practice in Citizenship Education* (Washington, D. C., A Report to the American Youth Commission of the American Council on Education), p. 8.

The following activities of direct concern to the science program have been carried out by students in various parts of the country: [7]

Sanitation projects based upon a survey of the community
Distribution of pamphlets pertaining to rules and regulations for public health
Sponsoring clean-up campaigns
Sponsoring smoke-abatement campaigns
Providing clothing, food, and toys for less fortunate children
Preparation and distribution of pamphlets dealing with food and diet
Campaigns against tuberculosis and typhoid fever
Elimination of traffic hazards

Various resources of the community—museums, libraries, botanical and zoölogical gardens, testing laboratories, bureaus of inspection, purchasing bureaus, health department laboratories, and the like—could be used to furnish educational experience and training for high-school students. Such work must be of real value, not merely "busy work" or "exercises"; it must not be done by students in competition with or at the expense of regular workers; and it must be supervised with reference to educational ends.

An illustration in the area of health. The problem of health, which in one form or another runs through many of the community activities already listed, has particular significance for science teaching. Usually also this is a problem which has meaning, in greater or less degree, to adolescents and, seen in its wider relationship, includes in addition the appeal of social contribution.

The adolescent has had enough experience to know that the sick person or the invalided, incapacitated person is a burden to others for care and support, and that he is a source of worry, solicitude, shared distress, and so on. He also knows that the sick person, where "communicable diseases" are involved,

[7] See Paul R. Hanna, *op. cit.*, pp. 95–117.

is potentially a menace to the health of others. Not so commonly recognized is the fact that maintaining health is in many respects possible only through community or social agencies and through comprehensive health programs involving and affecting entire populations.

This area is therefore chosen as one which well illustrates the rich potentialities of science teaching for developing effective participation in community activities. Any one of a number of areas could be used equally well; a study of housing, for example, would lead to many of the same problems and to others as valuable for purposes of science teaching and meeting the needs of adolescents in the area of social-civic relationships.

In most communities the adolescent is constantly exposed to practices affecting health and hygiene adversely or to controversies which bear more or less directly upon health. Examples of such sources of dispute are common. Some, for example, grow out of proposals for change, the introduction of inventions, the application of scientific ideas to various social problems, and so on. The taxpayer is assessed for sewer enlargement; the farmer or dairyman has to have his cattle "tested," and sometimes destroyed; quarantines or legal restrictions on hours of work force workers to lose wages; compulsory window screening puts the householder to expense; compulsory old-age or health insurance forces one to gamble against unpredictable and uncontrollable contingencies; the landlord is compelled to alter his building or to install equipment that costs more than he is likely to get back in rentals; child-labor laws deprive the family of possible earnings by children; the dog-owner is required to use a muzzle or leash. These problems constitute excellent points of attack for community study by the adolescent.

Teachers might well discuss the workings of health provisions in the community (and in the school plant itself): water supply, fire prevention, traffic regulation, accident prevention, the abatement of noises and of air contamination through

smoke, and so on, as they bear on the physical integrity of human beings. These are definitely social problems and the issues which they raise lend themselves to at least vicarious participation by the students, and to conceptualization in terms that are at the same time social and scientific. Still other controversies which prove vital with some classes and in some communities grow out of questions of cremation, autopsy, crime, child-labor restrictions, housing, vivisection, birth control, censorship and prohibitions, eugenic measures, euthanasia, and the like.

Whenever such issues arise, individuals are impelled to rationalize the procedures, rules, or proposals they have been accustomed to approve and to discredit new or opposing ones. The controversy is in most cases carried on in a way to manifest vigorously and unequivocally the existing convictions of the participants and only rarely to clarify their judgments. The alert science teacher can take advantage of the interest aroused by such disputes, whether they originate within the school or in the community outside. These situations are turned to advantage not so much in the expectation that the students will learn the correct doctrine or the correct solution as in the hope that they will come to a clearer understanding of (*a*) the factors essential to a scientific approach to controversy, (*b*) any contribution that the existing state of science may make to the specific issues, and (*c*) the wider implications of the problem. The science teacher who takes cognizance of such controversies should insist upon the validation of basic assumptions. What *are* the facts? How are they ascertained? How reliable are they? Are there secondary premises purporting to be facts? Are there other pertinent facts? What besides "facts" are necessary?

The science teacher will normally have his own views on these problems. And all of the discussions and disputes will have, in addition to the basic problem of facts, many involvements with local organizations, institutions, traditions, and interest groups. The teacher should be careful, however, to

distinguish clearly between his own judgments and preferences, on the one hand, and what "science" has to say in the premises, on the other. For science claims no authority in the making of value judgments; it claims consideration only when "facts" are involved. The student in the secondary school can understand increasingly why facts have to be agreed upon before attempting to evaluate beliefs and convictions, traditions and customs, habituations and tastes, vested interests and emotional fixations. And many students at least can come to understand that "science," or the use of intelligence, progressively encroaches upon "truths" formerly considered ultimate or fixed for all time.

In the immediate school community also there are opportunities for effective participation in meeting actually existing health needs. Laboratory work designed to develop understandings of techniques or of research methods which have disclosed important scientific principles can be effectively integrated with the school's practices in maintaining health standards and should eventually carry over into the community. The school lunchroom offers excellent opportunities for scientific as well as civic lessons. Balanced diets and nutritious food may be of purely personal significance, but protection against contamination can seldom be left to the individual, although every individual must learn to understand both why it is necessary and how it may be assured. Milk from the school lunchroom can be tested for fat content and bacterial count. The drinking water or the tap water lends itself to chemical and to bacteriological study. The sanitary arrangements of the school may be properly considered social problems, even when study of them leads only to improvement of the situation within the school. Preferably it should lead to setting up a model for the rest of the community to emulate, or some other and possibly more effective action in regard to analogous problems of sanitation in the community at large.

Several school systems have eliminated the feather duster from the janitor's equipment as a result of demonstration by

high-school science classes of the danger of its use. It may even be possible to turn the scientific scrutiny of the students upon the structure of the school program, with a view to more hygienic distribution of the various activities in relation to one another, to the lunch hour, to the gymnasium or playground period, and so on. In one high school boasting a modern "automatic" heating and ventilating system, teachers and students tolerated a temperature of 75° to 80° F. for two hours without taking initiative or responsibility for looking into the sources of the prevailing discomfort—it was against the rules to open the windows. A teacher of science who takes adequate cognizance of the social and institutional aspects of science in relation to health might conceivedly have checked more promptly on such a situation, in defiance of rules and janitors.

Wherever organized activities directed to maintaining health or preventing illness are carried on, in the school or in the community outside, the science teacher should find opportunity for the student to participate in the work or at least to observe the process. In connection with these activities students should be helped to get some conception of statistics as they relate to community health. Intelligent interpretation of statistics is peculiarly difficult, and statistics are subject to abuses which should be made explicit. The science teacher can call attention to the distribution of morbidity and mortality rates by states, regions, classes of the population; discuss some of the evident causes of differences; and raise challenging questions as to the possible significance of the observed variations. Are there discoverable relationships between the health status of groups and their modes of living, housing, sanitary conditions, occupations, incomes, nativity, political or religious views? Why is the infant death rate twice as high in some parts of the country or in one part of a given city as compared with other parts of the same city? Why is there endemic smallpox in some states and none at all in others? Why is there so much more diphtheria or typhoid or trachoma in some regions or some sections of the population?

Whatever the area chosen for study, whether health or housing or some other, the student should be helped to gain a conception of the social dependence and social interrelatedness of science. It has been customary in the teaching of general science and biology to call attention to the relation between health and such sanitary arrangements as adequate water supply, disposal of wastes, and drainage. The chemistry teacher puts in a good word for the virtues of chemical knowledge in furnishing suitable sterilizing agents; the teacher of physics stresses hydraulics, sterilization by means of heat and ultraviolet rays, and pumping systems. Equal stress, however, should be given (*a*) the idea that man's mastery over resources carelessly credited to "science" is a social product, (*b*) the idea that the opportunity to derive values from these "applications" of science rests not only upon the competence of experts but also upon elaborate organization and coördination of effort, and (*c*) the idea that effectiveness of any complex social program for the protection of community health and welfare depends finally upon the intelligent coöperation and support of individuals.

Generalizations and Inquiries Bearing on the Social Aspects of Physical Health

1. The physical health of the individual is closely related to the activities and well-being of other individuals.
   - *a.* A sick person is a possible source of danger to others.
     - (1) He may infect others by direct exposure, sneezing, spitting, and so on.
     - (2) He may be a source of infection indirectly (for example, malaria, typhoid).
     - (3) What are the rights and duties of healthy "carriers"?
2. A sick person is a burden to others.
   - *a.* A worker who is incapacitated is for the time being and by so much reducing the total social product, while continuing to consume.
   - *b.* Any person who is sick requires attention, extra service, and extra expenditures.

c. Any person who is sick is a source of worry or suffering to those who care about him.

3. The prevention of various kinds of sickness can be best brought about through community efforts.
   a. Safe water supply is more economically and more surely obtained on a large scale, as the community increases in size.
   b. The disposal of household and body wastes cannot be left to individuals except in rural regions.
   c. The extermination of infection-bearing insects can be managed only through community efforts over comparatively large areas.
   d. Vaccination and inoculation against specific diseases are more economical and more effective if applied on a large scale.
   e. Regulation of housing and of working conditions that affect health has to be entrusted to public agencies.
   f. Venereal diseases are most effectively controlled through community clinics and regulations.
   g. Should public authorities prohibit or regulate the sale of drugs that are injurious to the individual using them?
   h. Should the community require certificates of good health from those who apply for marriage licenses?
4. By means of vital statistics and hospital records it is possible to improve the health of the community.
   a. The isolated experience of individuals with sickness, food, and other factors relevant to health cannot be readily made of value to others.
   b. Mass statistics make it possible to find out whether the health of a whole people or region is getting better or worse.
   c. Mass statistics make it possible to find out how various conditions, practices, or measures influence the health of people.
   d. Is it right to put upon the individual or the physician the obligation to report sickness, recovery, births, and deaths, when the information is of no further use to those immediately concerned?
5. Scientific knowledge that bears upon health and sickness is derived from researches carried on by many kinds of scientists in various parts of the world and coördinated for various purposes.

a. Problems of health and disease are studied by chemical, physical, electrical, bacteriological methods in laboratories, as well as by the observation of sick people in hospitals and clinics.

b. Important medical and hygienic discoveries are freely and promptly made known to physicians and other health workers through publication in journals in all languages.

c. Important knowledge from various sources sometimes enables physicians, nurses, and other health workers in all parts of the world to improve their methods of dealing with sick people or of preventing sickness (for example, iodine, vitamins).

d. Some important discoveries can be applied only after the elaboration of complex systems for the production and distribution of various appliances, drugs, or other preparations (for example, U-V lamps, arsphenamin, insulin).

e. After a person has died, what good does it do to explore the inside of the dead body?

f. Why are there so many different systems of medicine?

g. How can it be determined that one system is superior to another?

h. Why cannot doctors always agree on what to do in a particular case?

6. Some of the differences among human beings appear to be inherited, so that certain qualities, characters, or capacities would be present or lacking in individuals, no matter what their living conditions.

a. Can any inherited defects or deficiencies be remedied by suitable treatment or training?

b. If each person is unique, is it not right for each one to make the most of his inherited capacities without regard for others?

c. Does sickness of either parent ever cause sickness in the offspring?

d. Is it right for individuals who inherit defects to reproduce themselves (that is, to give birth to other individuals likely to have the same defects)?

e. Is it right to forbid the giving of information on how to prevent conception?

f. Is it ever right to interrupt a pregnancy or prevent the development of a foetus?

g. Do public health work, preventive medicine, protection against accidents, and similar social aids to the individual lead to degeneration of the human race by preserving the weak, incompetent, or unfit?

THE REGIONAL SURVEY

Closely akin to projects directed largely toward the improvement of the school and the local community is the regional survey, which has somewhat wider implications. The physical and economic geography of the region and arrangements for community health and safety are phases of these surveys in which the science teacher may be of special help. Such studies appear to be more common in England than in America. The recent land-utilization survey in England was carried out through the coöperation of the school children in every locality. Instances of similar work elsewhere have come to the attention of the Committee. A science class in Alabama made a soil-conservation study in the locality and took measures to stop erosion at the places where the need was greatest. In one experimental college sophomores were given the opportunity to survey their home regions. Such surveys may become a central core in education for political life. In a recent article Lewis Mumford [8] urges them as a means of restoring reality to political life. He points out that:

Our educational systems are only beginning to make use of the local community and the region as a locus of exploratory activities: but before the resources and activities of a region are treated as abstract subjects they should be understood and felt and lived through as concrete experiences. Beginning with the crawling of an infant in his home, the systematic contact with the environment should broaden out until it includes the furthest horizon of mountain top and sea: in a bout of sailing, fishing, hunting,

[8] Lewis Mumford, *op. cit.*, pp. 383–384. (Italics ours.)

quarrying, or mining every child should have first hand acquaintance with the primitive substratum of economic life: the geography and geology of the textbook should be annotations to these experiences, not substitutes. So, too, with work in the garden, the vegetable patch, the hayfield and the grain field: here is the very substance of regional life, and no system of education, no urban environment can be considered even remotely satisfactory that does not include these experiences as a vital element. *Child labor, as Karl Marx pointed out, will be an essential part in all education once the element of exploitation is removed from it.*

It usually happens that the more one learns about a region or a community, the more affection one feels for it. The adolescent might explore his immediate region, small enough to be grasped from a tower, a hilltop, or an airplane. By thus starting from a region, its activities, its people, its configuration, its total life, he may develop a cluster of images and experiences to which he can relate his further achievements in specialized knowledge. United with other people by a common feeling for the landscape and for the regional culture, the young person may join with them in community planning with a feeling of participation in something that all agree is for the common good.

A report of a recent survey [9] of the resources for learning in Alamance County, North Carolina, is suggestive of the rich possibilities of utilizing the community or region for educational purposes. This survey was made by a group of teachers and principals. The resources were classified under the following headings: social, physical and technological, historical, and school. Science teachers will be especially interested in the following lists of "physical and human elements" which are part of this community: [10]

[9] George Beecher, "Resources for Learning in Alamance Co., North Carolina," *Progressive Education,* Vol. 15, February, 1938, pp. 140–142.

[10] *Ibid.,* p. 141.

NOTE: In this issue of *Progressive Education,* which is devoted to *Schools and Communities,* will be found many illustrations of the utilization of community resources in the school program; for example, see the following articles:

Geographical and Geological. Piedmont, long rivers and fall line, heavy rainfall for water power and agriculture, much undeveloped land, mild climate, many minerals though few of economic importance, good building stone and soil areas. *Botanical.* Unusually wide variety in plant life, quick growth and adaptation because of long growing season, rainfall, and soil. *Sociological.* Large farm population, high per cent of whites and native born, high birth rate, and relatively high per cent of home ownership. Long history of waste in management of, or not developing soil, forests, pastures, live stock, use of fertilizer, local markets for consumption of local produce and manufactures. But excellent progress in management and in development of transportation, water power, textile and furniture industries.

In addition to the elements listed above, certain more technological factors also furnish valuable materials for helping the student to understand and take his place in social-civic relationships. Some of the more obvious educational resources for science teaching revealed by this survey are the following:

Farming. Erosion control, balancing crops with live stock, etc. *Use of Cellulose.* Cotton, textiles, hosiery, paper, rayon, etc. *Construction.* Roads, quarrying, brick and tile, etc. *Trades and Crafts.* Pottery, furniture, electricity, tobacco, etc. *Communication and Transportation.* Railroads, automobile, truck, airplane, printing, electrical, etc. *Scientific Leadership.* Colleges, experiment stations, extension work, Soil Conservation Service, etc. *Health.* City and rural water supply, school and county programs, food standards and inspection, etc. *Power and Mechanics.* Mills, garages, electricity, gas, steam, etc.

Morris R. Mitchell, "Taking Dewey Seriously," pp. 110–117.
Persis K. Miller, "A Community School in a Large City System," pp. 97–109.
Ruth Willard Merritt, "Community Education in Ellerbe, North Carolina," pp. 121–125.
Leonard Covello, "Neighborhood Growth Through the School," pp. 126–139.
For other striking illustrations of the use of communities as laboratories for the school see: W. H. Bristow and K. M. Cook, *Conservation in the Education Program, Bulletin* of the United States Office of Education, No. 4, 1937; also Samuel Everett and others, *The Community School* (New York, D. Appleton-Century Co., 1938).

Developing Characteristics of Personality through Participation in Community Concerns

In much of the preceding discussion, it has been taken for granted that the desirable characteristics of personality the teacher wishes his students to develop will emerge naturally and normally from the activities themselves without the necessity for directing the attention of students to them. As school life gradually extends to include concerns of the community with all of their human relationships, *it becomes impossible to avoid affecting ideals and practices of a democratic society*, and the teacher should keep this fact continually in mind.

An erosion control project, for example, has within it the elements necessary for contributing to all of the desirable characteristics of personality, and the teacher's methods of working with the students will determine how these characteristics will be built. His task shifts somewhat from what might be called "direct teaching" to guidance and counseling. The planning, execution, and evaluation of a project of this sort calls for reflective thinking, creativeness, and self-direction of high order. Carried on as a joint activity, it requires cooperative action and mutual tolerance, and consideration of its social consequences would aid the development of social sensitivity. Even enhancement of the student's appreciation of the esthetic aspect of experience is to be reasonably expected as he participates in creating or restoring the beauty of a hillside. Projects of this sort exemplify the almost limitless possibilities involved in an educational program in which teachers take seriously John Dewey's famous statement [11] made many years ago: ". . . The school is simply that form of community life in which all those agencies are concentrated that will be most effective in bringing the child to share in the inherited resources of the race, and to use his own powers for social ends."

[11] John Dewey, *My Pedagogic Creed* (New York, 1897. Reprinted by the Progressive Education Association).

THE WIDER COMMUNITY

The school can help to bridge the gap between early adolescent gangs and the social and civic groups to which the mature adult belongs. The older adolescent needs to grow out of the Boy Scout stage through stages where he feels himself part of the entire school group or part of a national youth or church organization, until he becomes mature enough to feel himself part of a political party, or a nation, or an international group.

The teacher should, therefore, help the young person progressively to develop attitudes and understandings that will be effective in always more complex, more comprehensive, and more heterogeneous groupings. For example, it is not enough to be kind to one's own kind—social sensitivity, tolerance, and coöperativeness must extend to people with strange dialects or even strange languages and skins of different color. Enlightened people see their interrelationship with others, even others distant in time and space, and understand the social significance of their actions. It is not enough to be well meaning; one must have the understanding of social-civic relationships necessary to the achievement of one's intentions. Such understanding depends partly upon ability to think about groups without losing sight of the individuals who make them up. The science teacher can help his students to think clearly about people in groups, and at the same time to recognize that these groups consist of unique individuals.

This chapter mentioned earlier the necessity of conceptualizing social-civic relationships because these relationships cannot be visualized as can face-to-face relationships. Social statistics is one of the tools of such conceptualization, and it is even more important that the student develop a grasp of social statistics in connection with his participation in the wider community than it is that he conceive of the local community in these terms.

The science teacher can make definite contribution in help-

ing students to develop the understandings in social-civic relationships essential to intelligent, socially sensitive action. As one means to this he should give consideration in his teaching to the social conditions that make possible the growth of science and the applications of science and to the social consequences of these. In general he should be associated in this work with a teacher of social studies, but there is much he can do alone. A number of generalizations and inquiries concerning the wider community and the part the sciences have played in it are discussed in the following pages. These should be taken into account in planning an approach to wider community problems and in evaluating the range of sensitivity students are developing:

A. The Dependence of the Individual's Material Well-Being upon Social Organizations and Relationships
B. The Sciences as Part of a Growing Heritage of Knowledge
C. Social Conditions as Influenced by Scientific and Technological Developments
D. The Life of the Individual as Influenced by Scientific and Technological Developments
E. The Democratic Control of Social Development

A. The Dependence of the Individual's Material Well-Being upon Social Organization and Relationships

Science teaching should help students to understand the relationships of mutuality upon which democratic living is based: What qualities and conduct make for common well-being and security? How have common problems been met through joint efforts? How have social organization and cooperation made possible utilization of the results of the sciences to reduce the dangers and the obstacles to human well-being? Though these questions might not be asked explicitly, they should be implicit in the work of science courses.

The student should learn that the availability of the results of scientific research depends upon social organization

and coöperation. That insulin is a means of controlling diabetes can be easily learned by millions of people. But a person who learns from his physician that he suffers from diabetes can make very little use of his knowledge of insulin if he is left entirely to his own devices. As a matter of fact, he gets a bottle of potent fluid from the druggist, and the presence of the bottle on the druggist's shelf depends upon a vast and intricate organization, involving hundreds of specialists in dozens of different fields.

This complex system depends on the existence of the meat-packing industry, which daily makes available the pancreas of each of several thousand cattle. It depends upon the existence of the drug industry, with laboratories engaging the technical services and expert understandings of chemists, pharmacologists, bacteriologists, physiologists, animal breeders, microscopists, experimenters, investigators, and others. It depends upon constant coördination of the work of these technicians with what is happening in hospitals, clinics, universities, and research laboratories. It depends upon an extensive distributing mechanism enabling hundreds of products to reach dealers in all parts of the country. It depends upon a still different mechanism to inform physicians of the availability of the product, its characteristics, special merits, and limitations, and to give directions for its use. No individual, however well informed on the day-by-day findings of science, could by his own efforts alone take advantage of more than an occasional bit of the knowledge available in this field.

The teacher may help his students to learn that the use of the sciences has made it possible for larger and larger groups to coöperate in achieving common objectives. Civilization, which grew out of aggregations of human beings in cities, rested for centuries on the backs of slaves. The sciences, developing with the development of cities, have eliminated every social justification for slavery or for the exploitation of some for the benefit of others. Further applications of the sciences

may be used to eliminate the causes of conflict and mutual destruction, if men are willing to devote themselves to the problem.

Generalizations and Inquiries

1. Living and working in groups enable people to accomplish tasks too large or too difficult for individuals to carry out alone.
   a. The use of science in practical activities increases the division of labor and specialization of all kinds and makes possible mass production.
   b. Extreme division of labor tends to reduce the tasks of more and more individuals to simple repetitious processes, which are easily carried out even by children and less competent adults, but which are not stimulating or interesting.
   c. Both for the sake of economy in utilizing limited resources in materials and personnel, and for the sake of efficiency in utilizing many varieties of skill, knowledge, and talent, it becomes necessary to organize as social services forms of activity that were formerly carried on by individuals on their own initiative and responsibility—such as education, sanitation, medicine, road-building, weather forecasting, various forms of research.

   The benefits of scientific specialization and interchange of services are possible only when large numbers coöperate.
   a. In order to make use of scientific principles and methods in production, transportation, and communication, it is necessary to have large and complex organizations of many kinds of workers and machinery.
   b. Each specialized worker has to depend upon others and upon some organization of effort to make his work of value, and indeed to get a chance to work at all.
   c. The interdependence which results from division of labor extends to different occupations, regions, and even nations.
   d. Division of labor makes possible the use of many kinds of talents and many degrees of ability.
   e. As science makes available a wider variety of materials, men become dependent upon remoter regions for essential supplies, and eventually international coöperation is necessary to make the most of existing resources.

f. Because of the large scope of certain human problems, organization of scientific efforts on an international or world-wide scale has often become necessary.

g. What are the advantages and the disadvantages resulting when a family or a community is able to supply itself with everything that it uses?

h. Is it desirable to have the nation maintain economic independence of all other nations?

3. The growth of science, like the growth of civilization in general, has depended upon cities.

a. Cultural advances arise from the interaction of people living together in large numbers.

b. Modern technology has brought about rapid growth of cities, with corresponding decline in rural populations.

c. Technological advances, especially in transmission of power, in transportation, and in communication, make it possible for increasing numbers of people to have the benefits of close coöperation with others in various activities (economic, political, social, recreational, etc.) without being obliged to live in crowded areas.

d. There is a tendency for urban types of culture to spread into open spaces, at first through suburbs, then through new residential and industrial developments, and slowly into agricultural areas.

e. Is it better to live in the city or in the country?

B. The Sciences as Part of a Growing Heritage of Knowledge

Scientific knowledge is cumulative and part of a growing heritage of knowledge from which all may profit. Students should learn about the associations scientists have formed and about the means they have taken to share what is learned. They should study the social consequences of keeping advances of science secret—as in the case of research on war materials jealously guarded by the various national governments and in the case of products of scientific work kept from the public lest they render existing machinery and processes obsolete. They should come to see that the attic investigator or inventor is no longer typical of the "scientist." The individual

trained in a science concentrates upon research that is significant only as it is integrated with the work of others. Even where genius is at the center of a scientific enterprise, the project is essentially a group project. Science teaching should recognize and teach the coöperative and cumulative nature of science.

The student should also come to see that support of scientific work is a social responsibility. Since the practical benefits of scientific research often come long after the research is completed, industry, faced with the need for immediate profits, may not support research as well as people with a long view would desire. Modern science depends upon an economy which permits the selection of individuals to do work which is not immediately productive. Such a practice is, of course, not new: in all societies the scientist or artist has had to be excused from fetching and carrying and digging and sweating. He sometimes had a private fortune, like Cavendish or Franklin; he was sometimes subsidized by a duke or a prince, like Archimedes or Rumford; he was sometimes subsidized by a university or an industry, as are most contemporary scientists. The question of how scientific research shall be supported and of how its results can be spread most wisely should be taken up with students, recognizing the relative advantages and disadvantages of research supported by private benefaction, industrial contributions, and public funds.

Generalizations and Inquiries

1. The advancement of science and the utilization of science in modern times are both essentially social processes.
   a. Scientific research is made possible by the accumulation of earlier knowledge and experience of the whole race, through libraries, museums, universities, laboratories, and other institutions.
   b. The significant ideas and methods in modern science came through Greek and Arabic science, and medieval science, religion, philosophy, art, technology, and economic institutions.

c. Scientific research depends upon the constant interchange of ideas among people in different parts of the world, and often upon the direct coöperation of observers and experimenters in different parts of the world.

d. The training of individual specialists for their work becomes increasingly expensive in time, effort, and personal costs; it becomes also increasingly dependent upon the use of resources accumulated by society from the past and upon the exchanges and intercommunications of contemporaries, which are made possible by governments, endowments, associations, and other social agencies.

e. The outcomes of scientific research are often so highly specialized that they are useful only in connection with the outcomes of other research.

C. Social Conditions as Influenced by Scientific and Technological Developments

Some conception of the extent of the social effects of scientific and technological advances may be gained from the following list of changed conditions:

Increasing concentration of people in cities
Increased size of productive and distributive organizations
Increased division of labor and reduction of operations to stereotyped forms of extreme simplicity
Replacement of man by machines
Entry of women into work away from the home
Increase of social wealth and changes in the distribution of wealth
Increasing instability of economic equilibria—booms and depressions
Growth of publicly supported social services
Changes in leisure occupations
Spread of literacy—influence of the press
Intervention of governments in economic affairs

Not all of these are direct effects of scientific and technological advance; they are, however, the concomitants of a long process

of social change in which science and technology have always been important factors. Changes in technology had a profound influence in early societies through such discoveries as those of the wheel or of methods of extracting and working metals. The automobile and the light metal alloys are having the same kind of influence in modern society. The Greek scientists' ideas of the nature of the sun and the stars influenced religious beliefs, moral codes, and views of the world. The ideas of Copernicus and of Einstein have had similar influence in the modern world.

Scientific knowledge, technology, and scientific methods of thinking have been especially influential during the past three hundred years in changing men's conceptions of the universe, of the nature of social institutions, and of their own worth and importance. But changes of an ideological sort have not come about as rapidly as have changes in economic life. Conduct and ways of thinking are being adapted too slowly to keep step with changes in economic life. Those aspects of the culture most closely related to tools and techniques have tended to change more rapidly than those further removed, such as the government, the family, the school, and the church. These unequal rates of change in various parts of the culture have produced areas of lag, from which have developed social maladjustments and critical problems, such as crime, religious controversies, divorce, problems of localization and centralization in government, freedom and control in agriculture and business. Students may be aided to understand the causes of these social problems through study of the social influence of science and technology.

In this sort of study adolescents will probably take the opportunity to challenge certain institutions, like the church and the government. The demands made by such institutions may seem to the student not merely onerous or disagreeable, but often arbitrary and unreasonable. Although the adolescent understands the warrant for the authority exercised by leaders in his own group, he finds it difficult to understand

the sources of law and authority in the larger democracy into which he is now growing. Here he needs to know the justifications for the laws. He wants to be free to question, to criticize, to challenge the administrators as well as the makers of the laws, and to initiate changes through suitable instrumentalities equally accessible to others. The teacher should help the student in this process, understanding that the challenge is part of his growth. And the teacher should leave the adolescent as free as possible to question, criticize, and challenge the existing order of affairs, not desiring him in every case to come through to an acceptance of what adults accept. The institution of war, for example, might be questioned, criticized, and challenged, and students might organize to oppose war. The teacher's part in such a situation would be to stimulate and guide his students to make their judgments intelligently, with as much reflective thinking as they can bring to bear on the problem.

By increasing material resources and increasing potentially the leisure of large numbers the use of technological processes has potentially eliminated the basic problem of economic *need* and has made possible the participation of large numbers in forms of leisure pursuits or free activities that do, in effect, constitute the essential cultural interests of the people.

The inevitable attachment of value to the manners and preoccupations of the privileged classes from which the democratic revolutions sought emancipation has made many people confuse the plenty promised by scientific achievement with a large estate and plenty of servants for everybody. Popular preachers of democracy have sometimes misled the people under their sway into believing that full democracy would make possible a leisure-class life for all. This conception cannot be reconciled with the actualities of the situation. Neither the powers and resources nor the new concepts derived from the sciences justify it. Abundance for all, as promised by the new science and technology, means sharing by all in the necessary work, and this is in no sense the promised land of easy

living of the democratic orators of yesterday and today. It means release from want and the spectre of want through a rationally coöperative society. The science teacher in his contacts with the adolescent should clarify these issues by reference, not merely to the "plenty for all" ideal as represented by the manners and customs of the middle and upper classes, but to "plenty for all" as increasing abundance and release from want—as it may be made possible by the application of science within a society that will have learned to add a sense of individual obligations and responsibilities to that of individual rights which today overshadows all else.

The place of science in society has changed in the course of history, largely because, as a result of its own social effects, it has become a general necessity rather than as formerly a private indulgence or a luxury for those who could afford it. In modern urban societies people depend for their very existence upon the continuous application of research methods and results to the operation of productive and administrative organizations. And in the process of so using science these societies continually modify their cultures.

The social consequences of the applications of science include forms of interdependence unknown in earlier times. Through extreme specialization the individual is made helpless except as he can fit his skills into a complex organization of varied workers, but the organizing of varied workers is itself a task for another specialist. Responsibility for carrying on a multitude of services necessary for everybody is delegated to complex organizations; this puts the masses of the people in a precarious position with respect to the necessities. The failure of electrical service, for example, even for a short time, may paralyze an extensive area: light, heating, cooking, refrigeration, the operation of productive machinery are all suspended. Young people can understand these interdependences because virtually every one has experienced more or less serious interruptions of essential services; they have all heard discussed the suffering of the innocent public as a result of some

inconsiderate act of a far-away individual or group. Though a "strike" as a source of public inconvenience is more dramatically publicized through the usual news and publicity channels than is, say, a shut-down or a breakdown resulting from managerial shortcomings, the adolescent can sense in both cases the intricacies of relationship resulting from the applications of science.

It is a commonplace among the informed that the social consequences of the sciences impinge so variously in the different areas of life that they cannot be described as either good or bad, but most people, especially young people, want a categorical evaluation. Too often when they read about the evil results of science they see no alternative but to declare a moratorium on scientific research. The science teacher may help students to understand that science is in itself neither evil nor benevolent, that its social consequences depend upon the uses men make of new knowledges and techniques, and that these uses may be controlled in relation to larger social ends.

Students should learn in this connection that many evils have grown up along with urbanization and industrialization, because at each point those concerned, whether as enterprisers, workers, renters, consumers, or taxpayers, see only certain special and immediate advantages, whereas consideration for common long-time values has been confined to more or less detached humanitarians or reformers. Little or no effort is made to bring intelligence to bear on the situation. Innumerable instances of this may be seen in present-day living. In some regions today agricultural populations are being shifted to mill towns and no precautions are being taken to avoid the well-known undesirable effects of typical mill-town existence. Phossy jaw has been recognized and dealt with, but within twenty years, in precisely the same regions, analogous destruction has been permitted through the uncontrolled use of radiant salts in the making of luminescent watch dials. Knowing these things, students of the upper secondary levels

might well be challenged to consider possible undesirable consequences of the use of various technological advances and to make proposals for their prevention.

The applications of science that most immediately affect people's daily lives depend upon the possibility of distributing uniform products and services in large quantities. The printing press gives no benefits over the writing of books by hand unless many individuals are willing to read, or at least purchase, identical reproductions of any one book or newspaper. Profit from labor-saving machinery depends in large measure on the willingness of thousands to wear exactly the same model of hats or coats, to sit on exactly the same kind of chairs, sleep on the same kind of mattresses, eat the same breakfast foods. The benefits of railways are unattainable unless a considerable number are willing to ride at the same time in the same coach. Two or three generations ago the fear of "regimentation" by machinery was voiced in the glorification of the tool marks left by the craftsman; today most people accept such regimentation as a matter of course. But the claims of personality still persist.

The shifting attitudes of people toward various kinds of authority constitute one of the striking social changes in which science is implicated. It is beside the point that traditional authorities cling to their powers as a matter of course. Human beings are always the custodians of such power and authority as reside in an institution, whether the institution is the church or the family, the law court or the merchant, and these human beings will hold fast to what they have, even to the point of their own destruction. Science has a method for solving certain types of problems; its effectiveness has been demonstrated in special fields; it therefore challenges other authorities and other methods of ascertaining sound principles of conduct. Though this struggle among authorities is not really meaningful for the mass of people, they find it ominous and confusing. But that confusion constitutes a real danger to society. It is serious that the masses follow leaders

whose thoughts and understandings and purposes are medieval, unrelated to present actualities and needs. It is equally serious that in general they refuse to follow leaders who set up ideals and criteria very far removed from passion, fear, and envy. People cannot be expected to have regard for the kind of expertness which science yields unless they have experiences in which the value of such expertness can be demonstrated. This fact points to a definite and important responsibility of science education.

The young person of today has access to information concerning the social consequences of the sciences which his parents had little opportunity to get. If the science teacher will help him to see the value of this information and to interpret and use it intelligently, the next generation should be able to utilize the power science gives to much better advantage.

Generalizations and Inquiries

1. The extension of scientific techniques has shifted many occupations from the home to the factory and has at the same time created jobs for men, women, and children away from home.
   a. The work being done in factories, mills, laundries, and so on, is in general a substitute for the work formerly done on farms, in homes, and in shops attached to homes.
   b. The removing of more and more work from the home has reduced the amount of space occupied by the ordinary home.
   c. The increasing employment of women outside the home has reduced the amount of time available for looking after domestic matters, especially the care of children.
   d. Living conditions, economic conditions, and cultural changes have led to reduction in the size of the family.
   e. Scientific discoveries have made available special services for better health and more satisfactory living, but these cannot be supplied directly by the home or by individuals, so that schools, industrial organizations, newspapers, and other institutions are taking over functions formerly carried on by the home.

f. Improved methods of work free time formerly required for the production of goods. This may result either in leisure—which each individual can use for more schooling (going to work at a later age), playing, public affairs, cultivating special interests, and so on—or in intermittent involuntary idleness (unemployment).

g. Improved methods of work have increased the numbers of men and women engaged in service occupations rather than in the production of food, clothing, and shelter—such occupations as teaching, art, music, research, exploring, medicine, nursing, writing, dancing, and acting.

h. Some of the time gained from improved methods of work has to be given to political activities and responsibilities arising in the community because of the increasing complexity of relationships and the constant need for redistributing resources, skills, and even populations.

2. The need for placing machinery close to the steam engines in factories, and the need for placing large numbers of workers close to the factories, has crowded people together and changed the conditions of their living.

a. Bringing large numbers of people closer together has raised numerous community problems of sanitation, policing, housing, transportation, recreation, and human relations.

b. As population becomes denser, the uncontrolled individual use of the soil, waters, and other natural resources may lead to undesirable consequences for others or for the whole community.

c. Through science men have found the means for insuring suitable water supplies and other necessities for health, and for protecting concentrated populations against epidemic diseases.

d. Many of the scientific resources for protecting people against health hazards and for insuring various necessities have to be managed through the coöperation of many individuals, or through central or public agencies.

e. In what ways are individuals who have scientific knowledge better off than those who have none?

f. Do city dwellers have more freedom or are they more restrained than rural people?

g. Do civilized people have less freedom than more primitive people?

h. Does science tend to restrict personal liberties?

3. Mass production depends upon the use of power and machinery as well as upon the subdividing of tasks into their simplest elements.

a. Mass production promises to supply increasing quantities of desirable goods at lower costs.

b. Mass production makes it necessary for most people to accept uniform grades and styles in all classes of goods and services, including housing, transportation, amusements, and reading matter.

c. Does mass production bring about uniformity in tastes and activities to a degree that threatens individuality?

d. How do increasing mass-production methods promise more leisure for advancing the individual's particular tastes and interests?

e. How are the advantages of mass production to be more widely distributed?

f. Do the methods of mass production, with their specialization of functions, insure to all opportunities to do work related to their special abilities and interests?

g. Does the increased productivity of industry due to extreme simplification of the processes raise standards of living?

h. Why should competent men and women who do specialized but highly productive work in industry receive less pay than hand workers?

i. Why should women and children get less pay than men for doing the same kind of work?

4. The methods and applications of science influence available resources and ways of using them, and so have important effects upon life in communities and in society.

a. The applications of science may be used for improving and enriching the common life, but they may also be used in ways that are destructive.

b. Improved means of transportation make available greater variety of materials at any one place and sometimes greater abundance.

c. Travel and migration bring into contact, and sometimes

into conflict, the customs and the ideas of different peoples.

d. To what extent, and for whom, are the standards of living raised by improvements in methods of utilizing available materials and of controlling natural forces?

e. How can the techniques and engineering devices of science be used to solve social and community problems?

f. Can social-civic problems or conflicts be solved by the use of the intellectual methods of science?

5. The growth of science makes it possible to put the resources of any region to better use, but at the same time makes the inhabitants of any region more dependent upon the products of other regions.

a. Every nation can use science for the improvement of living conditions in its population.

b. Applying scientific knowledge to a small farm or shop can result in improvements—but only to a certain point; beyond that it is necessary to bring in materials, machinery, and skills from other regions and from other institutions, if advantage is to be taken of the new knowledge.

c. Utilizing the results of scientific discovery and systematic invention depends upon an extensive interchange of goods and services over a larger and larger area.

d. Should the North American Indians be encouraged to continue their own peculiar arts and ways of life or to become assimilated to the white man's civilization?

e. Is it possible to diffuse the benefits of modern science and technology among races that still live according to their ancient traditions?

f. Is it desirable to bring about greater unity in ways of living among all the groups in a community, or among all the races of the world?

6. The advance of science constantly shifts authority.

a. New discoveries and new ideas repeatedly disprove the convictions and beliefs held by people in an earlier period.

b. In modern times more and more people have come to think that rulers and other men in power are not necessarily wise or necessarily devoted to the best interests of mankind.

c. The history of science shows the desirability of being critical

of all traditions and beliefs, as well as being open to new ideas.

d. By means of science methods have been developed that seem to remain reliable under many conditions, although particular generalizations and conclusions are being constantly revised.

e. Since scientists as well as other authorities have made mistakes in the past, it is well to be modest regarding personal convictions and tolerant of the views of others.

f. Men have modified their ideas of theology and immortality in consequence of their experience and findings in the natural sciences.

g. By means of science it is possible to know with a high degree of certainty many matters about which people still dispute.

h. When scientifically established facts relating to a given question are known, does the individual have a right to his own opinion on it?

i. Since even scientists do not always agree, is it better for each individual to choose the authority he will follow, or is it better for all to follow the same authority?

D. The Life of the Individual as Influenced by Scientific and Technological Developments

The advent of modern science, with its applications, has not abolished the responsibilities or the rights of the individual, but it has changed them. In some ways the individual has more power, and in some ways he has less. In some ways he has more freedom, and in others he has less. If the young person is to adjust to this situation and make the most of it, he must understand what rights and duties the individual has in a democratic society based on the maximum use of the sciences in the service of man. In order to understand the rights and duties of an individual today, it may be necessary to see how they differ from the rights and duties of an individual a generation ago, or a century ago.

The new conditions brought about by the development of

the sciences and technology make it necessary to alter the concept of the rights and powers of the individual which most people hold. This prevailing conception was derived from a society in which individuals had relations with others almost entirely in terms of direct dealing, face-to-face negotiations, bargaining, covenants, contracts on the basis of an assumed "equality." But today the individual is no longer able to look out independently for most of his own interests. He has become specialized in his abilities, and his life has become more and more complex, more dependent upon the services of other specialists. Even the home, the stronghold of the individual, has lost some of its independence. Parents who have come to accept store clothes, canned foods, and kitchens without wash tubs suddenly discover that schools are looking after their children's dentistry, piano practice, and table manners. And it is not only the school that is taking over what were formerly domestic functions. In all directions the individual is forced, for understandable economic reasons, to give up his authority when he has lost his power of independent action. The parent and citizen cannot be as individualistic and as self-reliant and as enterprising as traditions assume. In order to make the most of the advantages that come through the sciences and technology he must give up some of his former freedom to act independently.

The science teacher might help his students to see how the government and other social agencies have been forced to assume responsibilities formerly resting upon individuals in order that scientific knowledge might be applied to the meeting of needs. Students should be led to consider how the work of experts may be organized, through governmental or other social agencies, so as to serve the common ends of many individuals. Consideration might be given to the licensing of medical practitioners, the establishment of crime-prevention bureaus, the establishment of government research bureaus and their control for the public interest.

It is often said that the individual has lost his uniqueness

and dignity in the modern scientific age. The science teacher may well discuss this subject with his students, pointing out that scientific studies demonstrate the physical uniqueness of the individual and that social processes, however complex, still depend for their effectiveness upon the unique contributions of individuals. On the other hand, the science teacher should not permit his students to remain blind to the fact that many individuals now get very little good from the results of the sciences.

In this country especially, which has carried the technical applications of science to daily life farther than any other, the individual's "rights" and "opportunities" continue to be treated in a purely negative way in accordance with the old traditions of political democracy. Most people therefore never do find out from the science teaching to which they are exposed why they do not share adequately the obvious benefits of science. Many acquire deep feelings of inferiority, and others acquire instead bitter feelings of resentment and hostility toward this "science" which does indeed create new kinds of gadgets and comforts and jobs, but which also arouses desires doomed to disappointment and creates unemployment, insecurity, and bewilderment. Science promises everything, but leaves the individual in many cases empty-handed. To realize this, one need but compare the boast regarding the "averages" in material gains (in this country as against other countries) with the distribution of these gains.

Only 15 per cent of this country's rural population, for example, is supplied with electricity, as compared with 50 to 90 per cent in various European countries. In the United States 80 to 90 per cent of the population is entirely without the means for what has been held up as a decent "American standard" of living, notwithstanding the presence of soil, mineral, and power resources several times as great (in proportion to population) as those of most other countries; notwithstanding the fact that "science" has increased the productivity of the unskilled or semi-skilled worker by many hundreds of

per cent; and notwithstanding the fact that a larger proportion of the population of this country than of any other country has the benefits of "higher education."

The advance of science and technology has brought diverse races into coöperation and into competition in such ways as to make the problem of race one of the most perplexing of social problems. The individual in America forms attitudes toward other races that are profoundly important for the future of democracy. The science teacher can help his students to form these attitudes in the light of the best scientific knowledge of racial characteristics and differences. The attitudes of the American toward the Japanese, the Brazilian, the Russian, and men of all other countries are socially significant even if he never sees one of these nationals, for the action of America in case of international rivalry will depend to a large degree upon these attitudes.

Generalizations and Inquiries

1. Research and the applications of scientific findings bring about conditions in which no individual can be expert enough to look after his own interests by himself.
   a. The specializations in knowledge and skill remove the individual from contact with raw materials, processes, and sources of information outside his own specialty, so that he cannot protect himself alone against adulterations, quackeries, and other misrepresentations regarding various necessary supplies and services.
   b. The development of large-scale industry, transportation, and commerce has led to the rapid exhaustion of forests, coal, oil, other minerals, and other natural resources, as well as to the contamination of rivers and beaches, to the detriment of people at great distances or of coming generations.
   c. The increasing complexity of commerce makes it necessary that some central or common agency set standards for weights, measures, and quantities, and eventually international agreements regarding such standards become necessary.

d. Increasing specialization and variety of occupations make it necessary to set standards and to define responsibilities for various occupations and professions.

e. Why should governmental or other social agencies license workers in some occupations but not those in others?

f. The confusions brought about by new complexities in living and by the movements of peoples into new kinds of cultures have led to great increases in crime as well as in other maladjustments.

g. Scientific studies have become necessary not alone for the detection of crime and criminals, but also for understanding the causes of crime and ways of preventing it.

h. Should governmental agencies supply individuals with scientific information regarding goods and services offered in a free market?

i. Should government research supply scientific aid to private business?

2. The growth of science makes more and more individuals highly competent and authoritative experts in some specialty, and at the same time makes each individual uninformed on more and more subjects.

a. Specialization makes possible a very high degree of expertness in some narrow field for people of no extraordinary ability.

b. The judgment of the expert is more reliable in his own field than is the judgment of the layman, but it is not necessarily better than the judgment of other laymen on lay problems.

c. It seems to be good practice to seek the counsel of experts whenever it can be had.

d. If most people are not themselves highly trained, can they have sound appreciation of what expertness really means?

e. Because so many people do not understand the methods and principles of science, they either accept uncritically whatever they hear in the name of science, or else they are hostile to science for fear of the misuse of the power it yields by people they do not trust.

f. Is the specialist always trustworthy as well as competent?

g. How can honest scientific experts be distinguished from quacks?

h. What is the layman to do when the experts do not agree?

3. The effects of the sciences may increase or decrease regard for the individual.
   a. Scientific studies of human beings demonstrate the uniqueness of each individual.
   b. Science is analytical; it is developed by breaking down major problems and assigning smaller and smaller parts of the total task to individual workers, so that almost any individual may make fractional contributions of value to the whole.
   c. Science is critical; it proceeds by constantly revising previous generalizations and conclusions, so that while only a few individuals may be able to make valuable criticisms, all have to be heard.
   d. Extreme subdivision of work often leads to excessive strain through monotony, as well as through speeding up.
   e. Extreme specialization may lead to satisfaction in a high degree of competence, but it may affect the health and self-esteem of the individual unfavorably because of the trivial character of his work and because of his sense of dependence on others.
   f. The monotony and fatigue that accompany much of the industrial work developed under the influence of science lead workers to seek for passive forms of entertainment and recreation.
   g. Is a scientific way of thinking due to inherited capacities or peculiarities, or is it something one acquires?
   h. Are all individuals capable of becoming scientifically analytical, critical, open-minded, etc.?
   i. Are individuals of all races capable of becoming scientific?
4. Inter-racial relationships are of increasing importance in modern society.
   a. Directly and indirectly, travel and trade bring peoples of all races into more or less close contacts for all kinds of dealings.
   b. The concept of race is based on the existence of distinguishable physical types.
   c. Races are classified on the basis of various physical traits, some of which are common to several groups, so that no classification can entirely separate races into mutually exclusive groups.

d. There is often more variation of individuals within a race than there is between the averages of two races with respect to a given trait.
e. Is there any race that can thrive equally well under all kinds of environmental conditions?
f. Is there any race that is superior to all others?
g. When two or more races occupy the same region or country, is it necessary for one to dominate?
h. How does intermarriage between races affect the characters of the offspring?
i. Is the number of distinct types of human beings increasing or diminishing?

E. The Democratic Control of Social Development

With all its emphasis upon freedom of action, freedom of enterprises, and freedom of movement, the democratic tradition assumes, nevertheless, a certain rigidity in framework, a certain permanence in the pattern of work, of trade, of man-to-man dealings, and of administration. The scientific advances that came to modify agriculture, industry, and all other technologies during the nineteenth century set in action various forces that conflict sharply with that tradition. One task to which the adolescent in a modern democracy needs to be directed is that of retaining the basic values of the democratic ideal, at the same time making use—democratically—of the forces that science has let loose.

There is no doubting the fact of social change, or the fact that a measure of control over social changes is needed. The science teacher may do something to help students understand the causes of social change and the possibilities for control over it. Through study of the social consequences of technological development, students may see that inventions have been one cause of social change, and that social inventions have lagged behind technological invention so as to cause serious maladjustment. From this, they should be led to consider the possibilities for controlling social change intelligently through social planning. Reports of local, state, and national research

and planning agencies should be utilized. An abundance of such material is available from hundreds of city planning agencies and more than forty state planning boards concerned with public works, land use, transportation development, population trends, distribution of industries, and administrative reorganization.[12]

One of the obstacles to intelligent and democratic control of social change is propaganda. Propaganda is likely to be found wherever there are points of conflict in society, for controversy emerges at these points, and propaganda is a weapon of frequent resort in controversy. The science teacher should help students to learn better ways to resolve conflicts. Students should study propaganda so as to be armed against it. They should learn that in recent times it has been increased in extent and effectiveness through scientific aids to communication, such as the modern newspaper, the film, and the radio, and through increase in knowledge concerning the human organism, its emotions, and its reactions. The science teacher can help to make young people proof against propaganda by teaching them how to evaluate authorities and how to read critically, and by guiding them in the development of habits of reflective thinking on social problems.

Essential to the democratic control of social change is an electorate which regards laws as the product of a social process and as needing revision when social change takes place. The science teacher should teach his students that the processes of democratic society are to some extent similar to the processes of growth in science, in so far as each is concerned with the continuous revision of laws and regulations. The laws of society, as generalizations of suitable conduct or as working regulations, come increasingly to be accepted as tentative ex-

[12] United States National Resources Committee (Washington, D. C., Government Printing Office): *Regional Factors in National Planning and Development,* 1935; *Regional Planning,* Part I, "Pacific Northwest," 1936; Part II, "St. Louis Region," 1936; Part III, "New England," 1936; *State Planning,* 1935; *State Planning, Programs and Accomplishments,* 1936; *Technological Trends and National Policy Including the Social Implications of New Inventions,* 1937.

pedients designed to serve recognized *common ends,* rather than as declarations of the *ultimate right;* in this respect they resemble the working hypothesis of scientific research. The teacher of science and the student need to recognize that the "law" is man-made, that it involves a margin of error, and that it is subject to revision—this not merely because men expect to know better next year, but also because conditions are constantly changing and therefore call for new treatment. Revisions follow prescribed procedures, but everybody is free to suggest changes when he finds the workings unsatisfactory, just as anybody may criticize a scientific hypothesis that fails to fit all the facts.

The free questioning of existing practices, the free discussion of proposed theories and interpretations, the planning of experimental tests of divergent or conflicting hypotheses, the reliance throughout upon various prior generalizations accepted for the time being without question, the readiness to alter or replace earlier generalizations, all represent significant features of being "scientific" in terms the students can understand and value. The need is, first, to carry this process over into the field of civic relationships and differences and into areas of controversy bearing upon common concerns, and second, to develop an appreciation of the superiority of this process to others for the enrichment of human life. The active participation in the process by students on a basis of mutual respect should be a valuable education in democratic citizenship and in the cultivation of regard for the individual.

Generalizations and Inquiries

1. Use of scientific knowledge and scientific methods makes possible a democratic control of social change.
   a. Social changes result in part from technological development.
   b. Social maladjustments often occur in periods of rapid social change.
   c. Social invention lags behind technological invention.

d. Why is it that western culture is changing so rapidly?

e. Are all parts of western culture changing equally rapidly?

f. Does social planning play the same part in the life of a nation as careful planning plays in the life of an individual?

g. Propaganda has increased in extent and effectiveness through applications of the sciences.

h. By means of science it is possible for the small person to employ violence as effectively as a large one. Thus the advantages of personal physical strength are largely neutralized.

i. Modern fighting machinery, in the economic field as well as in the military field, is destructive not alone to those against whom it is directed but to the rest of the population as well.

j. Because of the increasing interdependence of all sections of the population and of all nations, the use of violence in the settlement of disputes becomes more and more futile and inconclusive.

k. How is it possible to distribute the gains that the sciences make possible in civilization without increasing the power applied to destructive conflicts?

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VII

MEETING THE NEEDS OF ADOLESCENTS IN ECONOMIC RELATIONSHIPS

INTRODUCTION

It is generally recognized that the world is in a period of economic readjustment. Adolescents now in secondary school will shortly be confronted with the responsibility of dealing with the problems of this readjustment—of grave portent in their own futures and in the future of civilization. The Committee has chosen in this chapter to treat first of the effects of the current period of economic transition upon the lives of students during their adolescent years, and to proceed subsequently to a comparatively detailed discussion of meeting those needs which are more directly related to the responsibility for readjustment of the economic order.

The Scope of Adolescent Experience in This Aspect of Living

In the nineteenth century the majority of boys in their teens earned at least a part of their living, and most adolescent girls worked in the household with their mothers. In other words, most young people used to achieve adult status between the ages of fourteen and eighteen by gradually taking on adult economic responsibilities. In nearly every case the exceptions were either incompetents, or members of that small privileged group pursuing higher education for the sake of an assured higher economic status. In brief, the ordinary adolescent was either already at work, or he was following an educational program the vocational relevance and economic possibilities of which he could himself identify.

But the past three decades have seen fundamental, serious,

and apparently continuing changes in this connection. Relatively fewer workers are now employed in agriculture and in the crafts and trades where young apprentices are customary. In business there has been an increase in the proportion of workers required for clerical tasks, handling and selling goods, and other types of activities demanding experience and education beyond the elementary-school level. Thus the effect of recent economic shifts (due largely to scientific and technological advances) has been to decrease the demand for the labor of adolescents.

Work opportunities for young people have been further reduced during the last six or seven years as a result of poor business conditions. Under what conditions these opportunities will expand again is not known. In part this uncertainty arises from the fact of change in the ratio of different age groups in the population. When the first census of the thirteen states was taken there were two individuals under eighteen years of age to every adult. Now there are two adults to every individual under eighteen. This change, coupled with those resulting from technological advances, means that fewer (in total number) of young people will be called upon to work, but it does not necessarily indicate that a smaller proportion of young people will have work opportunities.[1]

[1] The facts upon which this and succeeding paragraphs are based are summarized in *Recent Social Trends in the United States* (New York, McGraw-Hill Book Co., 1933), pp. 303–304. The following table shows the trend of employment of young people between 1920 and 1930:

Ages	*Percentage Employed* 1920	*Percentage Employed* 1930
10–14	6.0	3.2
15	22.8	11.9
16	39.5	24.8
17	50.3	38.8
18–19	60.0	55.3
20–24	63.9	65.7

During the depression the relative number of employed youth probably decreased further. When the figures given in the table are supplemented by

Modifications in custom and law have also had a part in bringing about reductions in adolescent labor. More and more frequently children under eighteen are legally excluded from active participation in economically productive work. The jobs in field, shop, and factory which they filled in the past, are today for the most part so organized and directed that a generation of earnest men and women have been trying to close them to adolescents because of the threat of degradation in actual working conditions.

The son of a factory worker no longer follows his father

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the fact that 60 to 70 per cent of the employed youth are at work on farms, it becomes apparent that the proportion of urban youth at work is indeed small: the proportion of youth aged 10–17 employed in urban "Middletown" in 1930, for example, was 1.66 per cent, while the percentage at work in the country as a whole, was 11.5 per cent. Commenting on this situation, Robert and Helen Merrell Lynd say in *Middletown in Transition* (New York, Harcourt, Brace and Co., 1937), pp. 48–49: "The diminution in employment of persons under twenty may not, however, be passed over as due entirely to such factors as child-labor laws and education. The child-labor law drops out as a factor when the child completes the eighth grade; and yet Middletown had at the time of the 1930 census roughly 6 per cent of its children fourteen and fifteen years of age, 18 per cent of its children of ages sixteen and seventeen, and 21 per cent of the eighteen- and nineteen-year olds who were neither in school nor employed. What we appear to be seeing here is the slow emergence of a social problem likely to be momentous in the future, namely, the presence in Middletown even in the prosperous 1920's of a jobless and schoolless population, an idle in-between age group commencing in the mid-teens and culminating in the after-high-school age of nineteen. . . . With the growing pressure for available jobs from the steadier workers past their teens, Middletown's industries may be absorbing less and less of the population under twenty, leaving a helpless group too old for school and too young to get jobs. Under the circumstances, the prolonging of schooling through high school and into college in the 1920's may represent not only a desire for more education but a slowly growing necessity to choose between school and idleness.

"The problem of idle youth was emphatically present in Middletown in 1935. Middletown blamed this entirely on the depression and regarded the preference being given to married heads of families in local reemployment as but a temporary necessity. It may be, however, that, with tighter competition for jobs as a more or less permanent aspect of the economy from now on, Middletown may have to face the continuing social problem of the too-old-for-school-and-too-young-to-work."

The fact that there is a large group of young people neither at school nor at work has been brought out clearly by recent studies. Even though secondary-school enrolments have increased enormously in the past generation, so that now about half of the young people of the country between the ages of 15 and 20 are in school or college, about one-fourth are still neither at work nor in school.

to the shop, helps him in his work, or learns his trade gradually by participation. The daughter of the household no longer finds herself fully occupied with the tasks that were necessary when the home was the center for a multitude of economically productive operations and mechanical aids were few. Now the young person on the farm is practically the only adolescent who generally assumes responsibilities for productive work. The city boy or girl is either wholly outside its sphere or, where child labor is still permitted, is carrying a crushing burden in attempting to perform the type of tasks imposed by industrial processes.

Since the adolescent today shares but little of the work experience of his elders, he has few opportunities to gain either a sense of identity with them and their interests or an understanding of adult economic activity through first-hand experience. Likewise he fails to achieve a sense of increasing adult status. In the present highly complex society, the adolescent usually does not look for his first job until he is about eighteen, and even then he is without reassuring experience of past success in adult affairs. He has had the advantage of a secondary-school education, but he has been denied one advantage that his parents or grandparents had as adolescents, that of passing through a "school of hard knocks." Despite the physical drudgery that thwarted the development of many young workers in the past, this experience was often less damaging to the spirit than the uncertainties and sense of inadequacy besetting the youth of today. They had some measure of economic security and surety of adult status that made them emotionally more stable and better adjusted socially than many young people who are now idle at home or remain in school only because they cannot find jobs. Obviously this statement carries no excuse for child labor, although work by juveniles would be an essential part of education if exploitation were removed from it.

This situation imposes new responsibilities upon the secondary school. Together with other social agencies, it must help the adolescent to solve his problem of achieving a sense of adult status under conditions different from those of the past. Further, it must help increasing numbers of young people to prepare—physically, intellectually, and emotionally—for competent and responsible participation in a world that now requires secondary education, adult strength, and maturity of social experience. The importance of these new functions of secondary education grows as an ever larger percentage of older adolescents remain in school.

The importance of the rôle that the adolescent plays as a consumer of goods and services stands in contrast to his minor rôle in the work of the nation. Although his father and grandfather at the same age were more independent economically, the modern youth is called upon to spend more money and buy more things. He does this in a society marked, on the one hand, by an increasing use of a variety of machines, chemicals, and prepared foods that challenge his discrimination, and on the other, by "high-pressure" salesmanship and a "let-the-buyer-beware" advertising system. Under these conditions the secondary school must help him to use intelligence in the choice of goods and services—to be an intelligent consumer both now and as an adult.

Finally, the adolescent is entering into his rôle as a citizen in a democratic society characterized by growing industrialization, more and more associational activity, and a marked tendency toward the solution of economic problems by governmental means. The application of the sciences to the control and use of energy and materials underlies many of these processes of social change. Consequently the secondary school must help the adolescent to see the way in which developments in the sciences and their applications affect economic life; otherwise he cannot understand and formulate intelligent judgments concerning such problems as capitalism

and other forms of economic organization, collective bargaining, public ownership, money and banking, and domestic and international commerce.

Summary of Needs in This Aspect of Living

What are the student's needs in this aspect of living? Four major ones implied in the preceding section are here distinguished:

1. THE NEED FOR EMOTIONAL ASSURANCE OF PROGRESS TOWARD ADULT STATUS
2. THE NEED FOR GUIDANCE IN CHOOSING AN OCCUPATION AND FOR VOCATIONAL PREPARATION
3. THE NEED FOR WISE SELECTION AND USE OF GOODS AND SERVICES
4. THE NEED FOR EFFECTIVE ACTION IN SOLVING BASIC ECONOMIC PROBLEMS

These needs, as indicated in Chapter II, are all personal-social in character. Most young people feel the first two needs very strongly because of the great value that contemporary society sets on economic competence. Though the other two are not so universally felt in the same immediate way, they are generally held to be socially desirable. But whereas the former needs may be conceived to be highly personal in reference, and the latter to derive largely from social demands, both in fact relate to both the person and the society in which he lives.

Thus, if it is socially desirable that the production of goods and services be further expanded, the school must help the individual meet those of his needs which at first seem more purely personal in reference—the needs for assurance of capacity to do adult work and for guidance and preparation for an occupation. For, if properly met, these needs may increase the individual's incentive to produce goods and services: the person who is sure of his adequacy in economic activity brings to his work an abundance of drive for achievement, and the person who has been properly oriented in his

vocational choice—who has chosen the kind of work for which he is best suited—is a more efficient producer because he finds satisfaction in his work. Thus needs which are at first primarily personal in reference come to have social value.

On the other hand, the needs for wise use and selection of goods and services and for effective action in getting economic goods, though apparently social in reference, are closely related to the person. For, if properly met, they may lead to increased economic security for individuals. The person who selects and uses goods and services wisely gets the most security out of his income, whereas the person who acts effectively and democratically in getting economic goods contributes toward making the economic system provide greater security for all. If more economic security is to be provided, individuals must be helped to meet these two needs. The individual is entitled to expect security within society, and society through its democratic institutions is entitled to expect and encourage individual incentive. Thus in the economic sphere the demands of the individual and of society are conjugate in the needs of the student and can be met through improved education for young people.

The Task of the Science Teacher

The purpose of this chapter is to suggest ways in which the science teacher can help his students meet their needs in the economic aspects of living, and to do so in ways to promote the fullest possible realization of their personal potentialities and their effective participation in a democratic society.

At the outset it must be admitted that the teacher is handicapped in this task. The secondary school in America is not organized to provide a rich and meaningful experience in economic life, nor does the average adolescent gain this experience elsewhere. School shops, laboratories, studios, and gardens may be used to overcome this limitation. (Perhaps the time will come when secondary-school students can participate directly in productive economic activity on a part-

time basis, through a kind of apprenticeship maintained and controlled by society in order to obtain educational values for young people. The science teacher working with students under such circumstances would have the opportunity and the obligation to help them interpret their work experiences.)

In addition to the limitations in the present school organization the science teacher is frequently handicapped by the narrowness of his knowledge and understanding of economic life. Though primarily a teacher of science, he should expand his education to include much of the area of economic relationships—particularly the field of technology and its social consequences. He may then coöperate with the teacher of social studies in the area of their common interest and responsibility.[2]

THE NEED FOR EMOTIONAL ASSURANCE OF PROGRESS TOWARD ADULT STATUS

The adolescent has a vital need for assurance of personal adequacy in the economic sphere. This need takes the form of a drive to participate in economic activities of value in the adult world. If the adolescent earns money, or carries responsibility for work important to adults, or participates with them in economic activity, he almost automatically gains that sense of achievement which is essential to his progress toward maturity. By thus carrying through, even on a small scale, an activity he values, he gains the emotional assurance of being able to function on an adult level.

During the period of adolescence there is enforced delay between the desire for adult status and its fulfilment, and the

[2] A short list of books has been placed at the end of this chapter as a guide for science teachers who wish to widen their understanding of economic relationships. The report on *Technological Trends and National Policy Including the Social Implications of New Inventions* (made by the Sub-committee on Technology to the United States National Resources Committee, and published in 1937 by the Government Printing Office, Washington, D. C.) will prove helpful to all teachers of science. This report, to which frequent reference is made in this chapter, should be in every school, available to teachers and to senior high-school students.

paralyzing forces of anxiety set in unless somehow the adolescent becomes sure of his ability to become an adult. Thus it is important that boys and girls experience economic activity which reassures them in this respect. In order to do this, activities need not serve as direct training for a specific trade or profession. But though they need not lead to the exact tasks at which the adolescent will work as an adult, they may be of value in helping him discover his tastes and abilities, and thus in preparing him for a choice of permanent career.

Emotional Assurance of Progress toward Adult Status Gained by Genuine Earning

In contemporary society the adolescent needs to experience genuine *earning* as distinguished from payment for merely nominal services. Moreover, he needs to earn money, not merely praise or blue ribbons or certificates of merit. For example, a boy from a well-to-do home had been performing a useful volunteer service in a library for several years, but he suffered from a sense of ineffectiveness—lack of conviction that he could do a man's work—until a "salary" of twenty-five dollars a month was provided. Only by this tangible recognition of his economic competence was he reassured on the score of his ability to become a man.

Young people on lower economic levels also suffer from a sense of inadequacy as well as from material privations. A recent study of boys and girls receiving relief through the National Youth Administration shows that these young people, though needing money for clothing, books, and movies, were in many cases suffering even more keenly from emotional insecurity than from actual want. They had been unable to get work and were gradually losing faith in themselves. Letters from several of them after they did find regular jobs showed an amazing growth in self-assurance.

The science teacher, of course, is limited in his opportunities for helping students to obtain paid work, yet often he

can do something. He can arrange to have a few dollars a month paid to some of his students for services as laboratory assistants, and he can aid a few in obtaining summer employment in industrial and research laboratories.

Emotional Assurance of Progress toward Adult Status Gained through Working at Adult Tasks without Pay

Although under present conditions earning money is probably the most effective way for a young person to assure himself of his adult status and economic adequacy, it is also important for the American school to give recognition to economically useful activities that do not result in immediate earning. Too much emphasis has been placed upon the value of money, and the distinction should be lessened between working for pay and working to prepare oneself to become a more valuable member of society, both in the economic and in the human sense.

The school can do something toward bringing about this desirable change in attitude by helping young people to look upon their education as society's investment in them and by encouraging them to take part in unpaid but adult status-giving activities of social significance (such as health and safety campaigns). The teacher should combat the idea that education is a kind of charity rather than a right; his students should come to realize that those who go to school and college represent an economic investment and that their educational activities thus have specific economic value, just as a sapling is of value though it does not become economically useful until it is a grown tree. In this way their success in school work may be held to demonstrate their economic adequacy.

It seems probable that the need for emotional assurance of adult status can also be met to some extent by school activities which duplicate useful economic activities outside. When a high-school senior who had been baffled by his diffi-

culties with a course in modern physics successfully reassembled an automobile engine in the shop, he told his physics teacher, "Well, I may not be able to do quantum mechanics, but at least I can earn my living at auto mechanics." By duplicating an economically valuable procedure, he had obtained the emotional assurance of a specific ability and had gained thereby a sense of power which not only yielded emotional satisfaction but also contributed to his social development. Such experience allays anxiety and makes possible the endurance of the emotional tensions of prolonged delay in the fulfilment of a wish; it also tends to enrich the ultimate fulfilment with added emotional values.[3]

The science teacher can do much to help certain of his students achieve a feeling of adequacy in economic life through such activities as analyzing and testing water, milk and other beverages, foods, soils, fuels, and ores; making soap, dyes, simple devices, and machines that actually "work"; electrical wiring and repairing; gardening; or stock-raising. Though a student should be sufficiently successful in his performance to gain the reassurance he needs, he should not be forced to pursue such labors monotonously to their dead end in a limited technical expertness. The teacher's emphasis should not be on whatever values may emerge from the acquisition of useful skills but on the emotional satisfaction and stimulus boys and girls derive from these activities—whether they expect to find their economic destinies in factory or office, laboratory or farm, store or studio. It is only when the young person is confident of his ability to maintain himself that he can accept support from others without feeling unduly dependent, unduly dominated, denied his proper status.

[3] This sort of dramatization of a desired occurrence is practised in both primitive and civilized life in circumstances where there is an enforced and prolonged delay between a powerful wish and the possibilities of its fulfilment. See Floyd Dell, "Adolescent Education," *Progressive Education,* Vol. 9, November, 1932, pp. 473–481.

Suggestions to the Teacher

1. *Appropriation for Laboratory Assistant.* Provision may be made in the annual school budget for a fund for student laboratory assistants. One school which has a regular appropriation of four hundred dollars gives employment (at such tasks as washing laboratory dishes, preparing solutions, repairing apparatus, and planning and building new apparatus) to as many as ten students at different times during each year. Some of these students derive a small steady "income" from this work during the entire school year, while others work occasionally. Moreover, the school pays by monthly check. One student acts as head laboratory assistant, allocating the tasks and coördinating the work. Other competent students assist in correcting laboratory reports, confer about them with fellow-students, and are even responsible for final approval. Aside from economic reassurance, this last procedure obviously has other educational values.

2. *Library Service.* One or more students may be given entire charge of the science library, assuming all the duties of a librarian. Incidentally, the student thus learns the library skills, from cataloguing to annotation. This service may also be paid for from a laboratory-assistant appropriation.

3. *Club Activities.* When students in a school camera club produce photographs or enlargements that command the respect of adults, they gain the assurance of economic achievement. Payment for occasional small orders for their work sometimes reënforces this assurance.

An *automobile club* which acquires a wrecked car from a junk yard, takes its motor apart, repairs and reassembles it, and finally makes it run also provides activities that help to satisfy this need. The adolescent is aware of how much modern society depends upon people who understand the automobile and can keep it in repair and so is reassured when he demonstrates his ability to render this service.

A *radio club* can also help to assure the adolescent of his ability to be economically self-sufficient, especially if its work includes learning the code, getting an operator's license, and building a sending set. In one school a young radio expert and enthusiast from a local university came one afternoon each week to lead a

radio club. Under his leadership the club members not only learned the code and built receiving sets but published a school radio magazine and a radio dictionary. Many club members obtained operator's licenses and built short-wave sending sets. One of them, whose set was honored with the designation of Operators' Relay Station (O.R.S.), assisted in relaying important messages during serious floods in the Ohio Valley. This member gets up in the early hours of the morning to "talk with" operators in other countries and now carries on a regular correspondence with two foreign operators—to the great benefit of his language work in school.

4. *Summer Jobs.* Opportunity to work during the summer may be obtained for a limited number of students in industrial or research laboratories. This work ranges from dishwashing to assisting in technical procedures, and the pay varies from nothing to a beginner's modest compensation. But the experience with professional work and people, coupled with the realization that he himself can do some of this work, gives the adolescent reassurance of his economic usefulness.

THE NEED FOR GUIDANCE IN CHOOSING AN OCCUPATION AND FOR VOCATIONAL PREPARATION

Meeting this need differs somewhat from meeting the need for emotional assurance of progress toward adult status through confidence in capacity to do adult work. Whereas the latter fosters self-confidence and releases energy for any vocation (or other activity), the former helps the student to discover the particular occupation or family of occupations for which he has aptitude and inclination and to prepare for some kind of vocational activity within it.

Even though only a small portion of all secondary-school students will enter occupations requiring systematic technical science training, all need vocational orientation and guidance. It is one of the responsibilities of the science teacher to help them all learn about the kinds of work open to people with a scientific training, the aptitudes and abilities

required, and the kind of preparatory training best adapted.

It is his further responsibility to start on their way the relatively small group of boys and girls who have tentatively chosen a vocation that requires specialized science training. Whether the secondary school should provide technical courses in physics, chemistry, and biology for such students is not yet certain. Even at the secondary-school level, they might get more value from courses designed for general education, supplemented by special reading and perhaps by extra classes to fill in gaps in their technical preparation. One thing is certain, however: courses designed as vocational preparation for a few students should not be forced upon those who have no vocational destiny in the sciences.

Suggestions to the Teacher

(Pertinent bibliographical materials and films are listed at the end of this chapter, page 293.)

1. One unit or section of the science course may be devoted to a discussion of vocations—the value of understanding the conditions of work in various occupations and the abilities required by each. If any of the students exhibit an inclination to explore the scientific vocations, the teacher may then provide them with a list, from which each chooses several in which he is especially interested for further study. Eventually the most interested students may report their findings to the class.

2. Representatives of the various professions and industries may be invited to tell the students about the kinds of work in which their science training will be of special value, what aptitudes and abilities are most useful in such work, and what further specialization is advisable in preparation for particular jobs.

3. Visits to industrial plants and to industrial and research laboratories suggest vocations to the students, and make it possible for them to think about these types of work more concretely.

4. The teacher can help the student profit from his contacts with persons and places (made in the course of intensive study of special subjects) in terms of vocational suggestions and data.

5. The teacher interested in the vocational orientation of his

students will find that even pure science subject-matter is not irrelevant. The study of spectra and of matter, for example, may stimulate an interest in physical research as a career; the study of mechanics and heat may lead to engineering; or that of biology and chemistry to the medical profession.

THE NEED FOR WISE SELECTION AND USE OF GOODS AND SERVICES

Today it is more important than ever before for people to understand the full implications of their rôle as consumers of goods and services. On the one hand, it is far more difficult now for the consumer to protect his own interest, and on the other, the social and economic bearings of consumption habits are far wider and much more complicated than in the past.

The modern adolescent is early involved in this problem because he is called upon to buy more things than his parents did during their younger days—both because fewer commodities are produced in the household and because social demands and conditions are different. For example, he has more incentive to spend money on commercialized amusements and on articles of personal adornment. Thus it is not only as a future consumer that he needs knowledge, habits, and attitudes to enable him to buy with discrimination and to find out for himself the things he really likes instead of yielding to social and commercial pressures. He must develop reflective thinking and self-direction in selecting goods and services with discrimination and regard for the social factors involved—a development to which the science teacher can contribute especially by helping him to be critical, to know about certain common things he buys, and to be socially sensitive in his purchasing.

The Protection of Consumer Interests

The consumer's problem in protecting his own interests has been made difficult by a marked increase in the range of

goods and services he uses and by the partial disappearance of that personal relationship with the producer or merchant which used to provide at least some safeguard. Even the grocer or clothing merchant now sells such a variety of goods that he knows less about any particular article and therefore takes less responsibility for its quality than he did a generation ago. Furthermore, both buying and selling are stimulated by advertising for which the merchant and consumer have little responsibility.

The science teacher should provide opportunity for students to analyze the methods used in examples of commercial advertising. Simple laboratory procedures, especially in chemistry, may be used to test the claims made for some of the materials that the student buys and uses. The laboratory may also be used for the manufacture of such things as cosmetics, tooth paste, tooth powder, and inks. The cost of the materials may be compared with the retail price of similar commercial articles. In this connection the student should be led to see that his production costs include only the price of raw materials and do not cover wages, land rent, building and maintenance of plant, distribution and selling of the product—all expensive items with which the commercial manufacturer and merchant have to reckon in determining their prices.

The emphasis should not be on making the student cynical about modern business methods or teaching him to make or test the goods he needs, but on making him realize that consumers can protect their interests by testing goods and setting standards. He should come to understand that the consumer may choose between alternatives: that at some times it may be wise to buy a cheaper or poorer article, and at others, a better or more expensive one.

The adolescent should come to know something about the desirable and undesirable qualities of textiles, foods, cosmetics, automobiles, fuels, and other merchandise in daily use; he should also know about standards in certain services,

such as those of the dry cleaner and the shoe repairer. There is value, of course, in detailed knowledge concerning foods and other articles frequently purchased, but even here a general knowledge of standards, grading, and specifications is more valuable in the long run. It is usually easier and more satisfactory, for example, to buy canned peas or a cut of meat according to a system of standards or grades than it is to make a selection on the basis of detailed knowledge.

It should not be inferred from what has been said about the education of the consumer that he must act alone to protect his own interests. The student should come to see the protection of consumer interests as a social problem to be solved by citizens in a democracy through the coöperative use of their intelligence. It is important for him to realize that under present conditions no individual consumer can be expert enough to protect his interests alone, and that social solutions of the consumer's problem lie primarily in legislation and consumer organization.

In many areas, consumers are banding together to hire expert advice or to purchase and distribute goods and services coöperatively. Students should learn about these coöperative movements and consider the social and economic consequences of their further development in this country.

He should also learn about such agencies as Consumers' Research, Inc., Consumers Union, and the American Medical Association, which provide information for the consumer's guidance; he should be led to discuss and estimate the reliability of the information dispensed by each. Thus he may come to see that the reliability of the information disseminated by an organization must often be weighed in terms of its special and sometimes private interests. Consideration might profitably be given to the question of whether the United States Bureau of Standards should make the findings of its tests of commercial products generally available. In this connection, too, visits to the laboratories of private testing agencies would be instructive.

LIBRARY OF THE UNIVERSITY OF ALBERTA

The other solution of the problem of consumer protection involves legislation. The student should consider the question of governmental regulation of advertising for the protection of health and governmental inspection and grading of commercial products. The problems associated with pure food and drug legislation constitute an appropriate subject for study. Consideration may be given to the possibility of consumer representation, along with labor and capital, on commissions and boards charged with the regulation of commerce.

The Social Bearings of Consumers' Activities

The wise selection of goods does not mean merely getting the most or the best for the least money; the effects of buying habits upon others become increasingly important. What are the results of buying the cheapest goods at all times upon wages and working conditions? Efficient and careful use of goods already acquired is also of social significance and may properly be expected of all intelligent members of a democratic society. The science teacher can help his students to develop efficiency and care in handling sporting goods, clothing, automobiles, household appliances, and many other products of technology.

The wise use of services includes attitudes of respect and consideration for employees and servants, and a discussion of these attitudes should furnish many opportunities for cultivating social sensitivity.

Suggestions to the Teacher

(Pertinent bibliographical materials and films are listed at the end of this chapter, page 294.)

1. Tests may be made of such commercial articles as tooth pastes and powders, soaps, incandescent light bulbs. No complicated testing process should be used, since the purpose is rather to help students become critical than to help them become technically competent.

2. Cosmetics, tooth pastes, tooth powders, inks, and the like may be manufactured, and the cost of the finished product compared with the price of similar commercial products. The student must be led to see that his cost covers only raw materials, and that comparison with the retail price of the commercial product merely tells what part of that price is accounted for by the cost of materials. It is even more instructive for students to study a cost analysis of some commercial product and determine what percentages of the price paid by the consumer go to the producer, to the retailer, to the advertiser, etc.

3. An analysis may be made of the reliability and accuracy of periodical and radio-program advertising claims, and advertising space and time may be simultaneously estimated as an element in costs. For example, two pupils may record the amount of time spent in advertising on several radio programs over a period of a week or more, taking notes on any apparently unscientific or extravagant claims.

4. Examination of the key words in some such advertisement as "Beer is Best" will bring out the way in which the various meanings of these words ("good" in this case) are used to make the advertisement carry a certain sense to the consumer.

5. A comparative chart may be prepared to show the cost of proprietary and non-proprietary articles. (See Stieglitz' *Chemistry in Medicine* and Chase and Schlink's *Your Money's Worth.*)

6. The work of organizations like Consumers' Research, Inc., Consumers Union, and the American Medical Association may be studied and reported upon.

7. Accounts of medical fakes and nostrums in the journal *Hygeia* may be summarized and recounted before the class.

8. Many students will want to prepare exhibits to demonstrate their findings in such studies as those suggested above.

THE NEED FOR EFFECTIVE ACTION IN SOLVING BASIC ECONOMIC PROBLEMS

It is generally agreed that despite the comparatively high standard of American living every man's need for economic goods is not satisfied as well as the country's capacity to produce warrants. Learning to select and use goods wisely

helps in obtaining more satisfaction from a given income, but there is also evident need to find ways in which either to increase most incomes or to increase their purchasing power—their command over goods.

Great strides have been made in discovering efficient methods of production; there is abundant reason to believe that if existing resources, both human and material, were consistently employed according to the best-known technical procedures, there would be a large increase in the amount of goods produced for the use of the common man. As a matter of fact, however, a considerable portion of these human and material resources is regularly unemployed; periodically this portion becomes very large, at great cost in human misery; and the introduction of improved products and techniques is often curiously delayed. Moreover, the amount of income distributed to a large part of the people is insufficient to purchase the goods required for a decent standard of living. In other words, certain basic economic problems have yet to be solved.

While the adolescent at the secondary-school level cannot be expected to do much more than lay a good foundation for continuing study of economic problems in their more complex ramifications during his adult life, there is evidence that in his later adolescent years he is both eager and able to approach them and may do so with genuine profit. And it is to be remembered in guiding this approach that in meeting the need for effective action (in getting economic goods) the citizen of a democratic society is coöperative, socially sensitive, tolerant, and intelligent. He sacrifices his own economic gain, if such sacrifice promises economic gain for society. Guided by the social ideals of democracy, he may refuse to circumvent a tax law or to make an easy profit at the expense of others. He endeavors always to be informed and intelligent on questions of social significance. He expects social and economic changes and labors in coöperation with

others to direct them toward the fuller realization of democratic ideals.

In a democracy the common man must assume responsibility for protecting and securing his own rights and those of his fellows. In terms of the present discussion this means that he must assume responsibility for promoting and evaluating attempts to solve economic problems. But to do this effectively, he needs to attain economic understanding. It follows that teachers in a democracy have an obligation to disseminate reliable information concerning economic life and to provide a forum for the candid examination of its rival interpretations. They must aid the future citizen in developing ability to detect economic misinformation and to puncture fallacious economic arguments and encourage in him a willingness to act upon the basis of tentative conclusions, arrived at through reflective thinking.

The educational system of the country is not now adequately fulfilling this obligation. Current restrictions upon the dissemination of facts concerning economic life and upon free discussion of their implications effectively deny to the citizen the possibility of attaining a clear understanding of the problems involved. In the interest of the improvement of American society every teacher should feel it his duty to play a part in rectifying a situation so contrary to the effective pursuit of democratic ideals.

In practice this means that teachers must acquaint themselves with facts not commonly known and with different points of view on economic problems.[4] They should be intelligently and, as far as possible, sympathetically aware of the conservative, liberal, and radical positions on economic issues, and they should attempt to see that these positions get fair and critical examination in their classes.

The science teacher can play his part by helping young

[4] Some books which may be of service to the teacher in this connection are listed at the end of this chapter.

people to gain an understanding of the effects of the sciences on the modern social order, especially their impact on its economic organization. Before the citizen can participate in fully effective action designed to secure for each the economic goods made possible by the country's capacity to produce, it is necessary for him to understand how natural resources condition economic activity, how energy and materials are controlled and used in economic production, how applications of the sciences increase control of energy and materials, and how social and economic conditions depend upon this use and control.

That such understandings as these are prerequisite for intelligent citizenship in a democratic industrial society may conceivably be questioned. The argument in favor of this position rests upon the case already made for the necessity of getting facts and making generalizations from them before it is possible to deal adequately with most contemporary problems in social-civic and economic relationships.[5]

Why, for example, is understanding related to the generalization, "Energy may be conveniently and efficiently distributed over long distances in the form of electrical energy," necessary for intelligent citizenship in America? The answer is that in this country there are several extensive conservation projects (such as the T.V.A. project, Bonneville, Grand Coulée, and Boulder Dam) in which the development and sale of electrical energy are important factors. The electorate has already decided to put money into these projects. It is also deciding, directly or indirectly, what use will be made of this energy: whether it will be sold directly to users, to municipal utility companies, or to private utility companies; and whether it will be sent long distances to industrial centers or to small decentralized industries. Answers to all these questions require judgment of value and knowledge of fact. Among other things they require understandings represented by the generalization quoted above. They also require knowl-

[5] In the first part of Chapter V, pp. 183–187.

edge of the fact that there are limits to the distance over which electrical energy can be distributed in competition with energy from local steam-electric plants. Though experts are expected to decide on many of the engineering problems in projects like these, the electorate must choose the experts, must know what kind of questions to ask them, and must be critical of them.

The science teacher can help to inform the future electorate through helping boys and girls to develop understandings related to generalizations like the one under discussion. Unless the generalizations presented in this section of the chapter prove valuable in helping the citizens of a democracy secure the goods which the country can produce, they do not belong in the curriculum.

In addition to helping the student to acquire understandings represented by generalizations like this, the science teacher may help his students to study the hindrances to maximum production of goods and to learn how the national income is distributed among the population. This he will probably do best in coöperation with the social-studies teacher.

If the teacher succeeds in making study in this area vital, most young people (coming as they do from families with less-than-average income) will raise insistent questions of action. "We are not getting our share of economic goods; what should we do about it?" This is a test for any teacher. Even the science teacher, who cannot claim to be as expert as the social-studies teacher in this field, should lend what help he can to his students in deciding what action they should take. Though he should, of course, endeavor to work with (and in most instances subordinate himself to) the social-studies teacher, yet even without such coöperation he can suggest kinds of action for study and discussion. For example, with the principle of collective bargaining established in law, it seems clear that young people of all economic groups should study labor unions and form tentative judgments con-

cerning their rights and responsibilities. And that great majority of young people who will probably enter labor unions should be encouraged to think about the place the union may and should occupy in their lives.

If it is agreed that the individual should know about the potential productivity of the country's economic plant and should be able to deal with the questions involved in making it operate more satisfactorily, the science teacher may be expected to help his students develop certain understandings, attitudes, and abilities discussed under the following six major generalizations:

A. Men Are Influenced by the Environment in Their Use of Energy and Materials.
B. Natural Energy Is Controlled and Used for the Purposes of Economic Life.
C. The Production of the Great Variety of Goods Now Used Depends on the Availability, Creation, Utilization, and Control of a Wide Variety of Materials.
D. Application of the Sciences Increases Control over Energy and Materials.
E. Social and Economic Conditions Depend in Part upon the Distribution, Use, and Control of Energy and Materials.
F. Conservation of Exhaustible Natural Resources Is a Social Responsibility.

Suggestions to the Teacher

The following discussion of each of these major generalizations gives an indication of its meaning and of ways in which the science teacher may help students develop related understandings. Obviously, the student will not suddenly grasp a major generalization. He will achieve the understandings it represents—with all of their richness of meaning and implications—through correlating the experiences gained while engaged on diverse problems and projects which lead to subordinate and less inclusive generalizations.

Therefore the discussion of each major generalization is followed by a list of typical minor generalizations which are logical subordinates. These lists are not complete, and they are not offered

as minimum essentials; some of the items included in them might be considered essential in the development of the major generalization, but not all of them. Also, undoubtedly many items of equal importance have been omitted.

Each major generalization is also followed by a list of activities [6] —suggested student problems, experiments, excursions—which have been found fruitful in helping students arrive at related understandings, together with accompanying abilities and attitudes. The understandings represented by a generalization are clearly not achieved by memorizing a sentence or a statement, but rather grow out of the student's solution of problems in which he is genuinely interested.

These lists carry no implications regarding the organization of learning activities—that is to be decided by the science teacher and his students. Some teachers might deal with the first major generalization in an instructional unit called "How the Environment Influences Man"; others might organize instructional units around topics that include material from other phases of economic life and other aspects of living, for example, "Climate and Health," "Environment and Culture," "The Technology of the Ancient Greeks." Any such plan would require selecting and listing suitable reading materials, visual aids, and the like; selecting and organizing learning activities in the form of problems, projects, and experiments; and devising some method for testing the student's ability to formulate and apply the understandings expected to grow out of his learning activities.

A. Men Are Influenced by the Environment in Their Use of Energy and Materials

The student should be led to understand the relationship between geographic and climatic factors, on the one hand, and man's material needs, his occupations, racial characteristics, and cultural forms, on the other. In the course of developing this understanding he may realize that differences in material and moral standards of living cannot be ascribed simply to racial or national differences which are independent of the natural environment—that many elements, including

[6] Visual aids and bibliography for each are listed at the end of the chapter.

climate and natural resources, enter into the determination of the "civilization" of races and peoples.

He should come to see the history of man in terms of man's long attempts to control weather, soil, sources of energy, and living things for his own benefit and that of his descendants. On the one hand, he should learn how the discovery and exploitation of new resources give men the power to expand industry and to support an increasing population; he should develop a positive feeling that greater use of the scientific knowledge already at their command would free men from the spectre of scarcity which was the necessary accompaniment of ignorance concerning the extent and use of natural resources in an earlier age. On the other hand, he should come to understand that the environment sets limits on this kind of expansion, that available supplies of energy and materials are not inexhaustible.

Tentative List of Generalizations Bearing on Major Generalization A

1. Geographical surroundings affect man's material needs and occupations, his racial characteristics, and his cultural forms.
   - *a.* Since soil, weather, and living things are important for the subsistence and health of human beings, men have always tried to control or adjust to these factors of the environment.
   - *b.* Differences in the quality and quantity of the production of various peoples are due in part to differences in the resources of their lands.
   - *c.* Temperate regions with variable climate are those in which agriculture, stock-raising, manufacturing, and other economic activities may be carried on most vigorously.
   - *d.* Large bodies of water are of service to man as a source of rain, regulators of temperature, an aid to health, a source of food, and an aid to travel and transportation.
   - *e.* The agriculture of the future may depend more largely upon crops from trees and vines, because of their greater yield and adaptability to soils not fitted for grains.
2. The sun is the source of practically all the energy that men use.

Illustrations of Possible Student Activities

(Pertinent bibliographical material and films are listed at the end of this chapter, page 295.)

1. Study the soil and climate of (*a*) the Sahara Desert, (*b*) the Arctic or Antarctic, (*c*) the tropics, (*d*) the local community. Relate what you find out to the plants and animals available in each area. Relate soil, climate, plants, and animals to the food eaten in each place, the building materials, textiles, tools, etc., in common use. Can you see any relation between the soil and climate and these elements of the civilization of the inhabitants?

2. In what ways does water constitute a limiting influence upon a civilization?

3. What environmental factors influence the culture patterns of a people?

4. Look up in an economic geography or atlas the density of population (in persons per square mile) in various parts of the United States and account for the differences in terms of soil and climate. Do any other factors play a part? Carry out the same study for the world as a whole.

5. Make a map showing the location of the great steel mills in the United States, and indicate the reasons for their geographic position. Do the same for the main centers of the automobile industry.

6. Study the three most important local industries to determine the reasons why they developed in this particular area.

7. Why have many textile plants migrated from the North to the South?

8. Examine a world map showing the areas devoted to the cultivation of sugar beets, and find out what factors of soil and climate account for their location.

9. Why are the wheat-growing regions generally located between latitudes 30° and 60°?

10. Explain how the small but constant natural fertility of New England soil is derived from the granite rock which composes its hills and mountains.

11. Compare the health statistics for people living in the city with those for people living in the country. Which group has the higher mortality rates, sickness rates? Which has more health

regulations? For which have more health provisions been made? Why? What differences do you see in the respective physical environments?

12. Compare the health statistics for people living in slums with those for people living in suburbs. In your opinion, how much of the difference, if any, is due to the physical environment?

13. Compare the stature of a large number of students whose parents are immigrants with the stature of their parents. Look up the results of similar studies. Find out how the stature of recent Harvard students compares with that of their parents. How do you explain these facts?

B. Natural Energy Is Controlled and Used for the Purposes of Economic Life

The student should know that coal and petroleum fuels are now the chief sources of energy and that their widespread use is due not only to their large energy content but also to the ease with which they may be transported and their energy made available. He should also learn that water power—transformed into electrical energy which can be distributed and used with convenience and efficiency—is again being used extensively over long distances.

In this and other countries there are great projects under way to conserve water for agriculture in semi-arid regions and to generate energy hydroelectrically for use in home and industry: it is of utmost importance that young people not only learn something of the technical nature of these projects but also become sensitive to their social significance. This sensitivity may lead them to support legislative measures designed to insure the use of these projects for the benefit of society.

It is important to bring out the fact that energy is required for such fundamental economic operations as mining, smelting, manufacturing, transportation, building, farming, and communication, and that the development of all these operations has depended upon the discovery and use of new and richer sources of energy. Class discussion may point to the

need for conserving present energy resources and the possibility of making usefully available those which lie in tides, winds, and direct solar radiation.

In order to develop these understandings, students will need to grasp certain fundamental concepts and principles of pure science, such as the principles of conservation of energy and matter, the second law of thermodynamics, the laws of chemical combination, and the simpler laws of mechanics, electricity, light, and heat. No one, for instance, can adequately understand the importance of sources of energy in modern life without some notion of the conditions under which they are converted into heat and mechanical energy and used to do work in industry. The teaching of facts and principles of pure science must be determined by the teacher in the light of the main purpose of his course.

Tentative List of Generalizations and Inquiries Bearing on Major Generalization B

1. The natural energy of fuels may be transformed into mechanical energy by means of some type of engine.
   a. Mechanical energy is transferred and put to use through machines.
2. Coal and petroleum fuels are now the chief sources of energy for industry.
   a. Fuels are a valuable commodity because they possess potential energy that can be utilized conveniently and economically.
   b. Potential energy must be transformed into some such form as heat or mechanical energy before it can be used for doing work in industry.
   c. The potential energy of fuels may be transformed into heat by combustion, the heat into mechanical energy by means of some type of engine, the mechanical energy into electrical energy in a dynamo, and so on.
   d. The widespread use of petroleum fuels is due to their large heat of combustion and to the ease with which they may be transported and their energy made available.

3. Water power is being made increasingly available to industry.
   a. The potential energy of the water behind a dam or at the top of a waterfall comes from solar energy absorbed in the process of evaporation at other places.
   b. The energy of water falling or flowing downhill may be used to operate turbines or water wheels, which may in turn be used to operate machines, or to operate dynamos for the production of electrical energy.
4. Energy may be conveniently and efficiently distributed over long distances in the form of electrical energy.
   a. The transmission of electrical energy over long distances makes it commercially profitable to utilize remote and otherwise inaccessible sources of energy, such as water power from reservoirs located in mountainous regions.
   b. What are the possibilities of power transmission by other means, for example, electromagnetic radiation?
5. Attempts to utilize still other sources of energy for the purposes of industry may be necessary in the future.
   a. The rise and fall of the tides provide sources of energy which may be made available for use in industry.
   b. The kinetic energy of the wind, derived from solar energy, may be utilized to drive windmills.
   c. It is possible and may become necessary to derive energy directly from the sun's radiation instead of indirectly as at present.
6. The operations of mining, smelting, manufacturing, transporting, building, farming, communicating, and the like have been developed through the use of new and richer sources of energy.
7. Should industrialists be responsible for conserving natural energy resources?
8. Should government compete with private industry in the exploitation of natural resources?

Illustrations of Possible Student Activities

(Pertinent bibliographical material and films are listed at the end of this chapter, page 297.)

1. With the aid of an industrial geography locate on an outline map the more extensive coal deposits of the United States.

2. What operations are used in the mining of coal? What are the more important hazards of the industry and how can they be lessened?

3. What industries other than coal mining are sometimes found in the coal-mining regions? Is this location related to the presence of the coal?

4. Use some type of calorimeter to determine the calorific value of various kinds of coal.

5. Make an analysis of different kinds of coal to determine the fixed carbon, volatile matter, sulphur, and ash.

6. Locate on an outline map the principal oil regions of the United States.

7. Make a "flow sheet" covering the operations involved in the refining of petroleum.

8. What methods are used for increasing the gasoline yield from petroleum?

9. Study some simple machine to develop the concepts of *force, work, power, energy,* and *efficiency.*

10. Observe the running engine of an automobile; then take it apart; put it together; and run it again.

11. Determine the mechanical equivalent of heat by means of a tube through which lead shot is allowed to fall a number of times.

12. Calculate the amount of work that a gallon of gasoline could do if all its available heat energy were converted into useful work. Are the gasoline advertisements accurate or merely the fine fruition of the advertiser's zeal?

13. Make a comparative study of the steam engine, the gas engine, and the Diesel engine in regard to (*a*) structure and principles involved in operation, (*b*) efficiency, (*c*) uses.

14. Mark on an outline map the more important natural and artificial water-power regions in the United States and other parts of the world.

15. How does water get its available energy? In what ways can water power be made available for industry? What difficulties seriously interfere with the full utilization of water power for generating electrical energy?

16. Study several electrical devices, such as the galvanic cell, the

dynamo, and the transformer, to develop the concepts of *E.M.F., resistance, current, electrical energy,* and *electric power.*

17. Why is the water power of remote mountain regions converted into electric energy before it is transmitted for use in industrial communities?

18. Determine the efficiency of an electric motor.

19. Why does industry sometimes convert coal into producer gas for use in an internal combustion engine although it could obtain the power more directly by burning the coal in a steam engine?

20. What power authorities (like the T.V.A.) have been or are being developed in the United States? Make a special study of one.

21. Look up the present status of the Government Passamaquoddy (Maine) project for the utilization of the energy of tidal motion.

22. To what extent is the kinetic energy of the wind utilized for doing the work of modern society?

23. What is the present status of the direct use of solar energy in a solar motor, or in other ways?

24. List all of the more important operations—in production and communication—which require the use of energy.

25. Make a study of all phases of the topic, "Government Competition with Private Industry in the Manufacture and Sale of Electric Power."

Excursions

1. Make a trip to the power plant of a local rapid-transit or lighting system, and trace the method by which the chemical energy of the coal is converted into electrical energy. From the number of pounds of coal used to produce one kilowatt-hour of electricity, calculate the over-all efficiency of the plant.

2. Visit an oil refinery to see how petroleum or any petroleum fraction is refined. If possible, visit a plant which hydrogenates petroleum or cracks it into gasoline hydrocarbons.

3. If possible, visit a coal mine, an oil field, a hydro-electric plant, an oil-burning locomotive or ship, a tidemill, a station at the urban end of a high-tension electric transmission system.

C. The Production of the Great Variety of Goods Now Used Depends on the Availability, Creation, Utilization, and Control of a Wide Variety of Materials

Modern industry depends upon iron and a few other metals; certain non-metallic materials (such as clay, sand, limestone, and sulphur) taken from the earth's crust; and some materials derived from the sea and atmosphere. Without understanding the reasons for the widespread use of iron and a few other metals, it is impossible to understand either the extent of a nation's economic productivity or the kinds of consumer goods it produces. Students should therefore realize that the location of industries for the production of these metals is generally determined by the relationship between the location of sources of ore, flux, and coal, and the cost of transporting these and the other materials needed in the production of a given commodity. They should also realize the vast variety of natural resources necessary to the production of manufactured goods, as well as what materials in soil and atmosphere are essential for the continuance of the plant and animal life from which important materials are derived—and they should understand how all these materials may be conserved or replaced. For it is upon these raw materials and the materials created from them that the availability of the kinds of things they need depends.

The teacher concerned with increasing the effective social participation of his students should help them to see the social causes and social consequences of the ways in which energy and materials are used and controlled—at the same time that they study the scientific facts and principles involved—though on occasion he may well ask about the extent of his responsibility in this connection. For example, the same process (the fixation of atmospheric nitrogen) is used in the production of both fertilizer and high explosives; it is the responsibility of the citizen to decide the ends which

control over materials should serve. But suppose students do become seriously concerned with such problems as the private manufacture and sale of munitions on an international scale. What should the science teacher do about it? Surely, he should not be content merely with inconsequential discussion when his students genuinely desire to make themselves socially effective in problems of this sort. Although the science classroom should not be made a recruiting station for one organization or another, the science teacher has the obligation to help them see that organization is an effective way of meeting certain problems and, if necessary, to remind them of the existence of student, church, and labor anti-war organizations, of patriotic organizations, and of organizations favoring preparedness.

Clearly the teacher should not dictate the specific attitudes to be adopted in regard to this or any other subject. Such a procedure is neither educational nor democratic; there is no way of knowing which would prove most consistent with the optimal development of the individual, effective social participation, or the use of intelligence. On the other hand, it is the teacher's task to see that attitudes are developed within a broad range of possibilities. For example, he should encourage the student to become "sensitive to the effects of his own actions as a citizen, producer, consumer, upon the welfare of others," as described in Chapter II. He should not attempt to inculcate specific attitudes on issues like collective bargaining, the child-labor amendment, or buying from chain stores, but it is his concern to see that attitudes do emerge and that these attitudes are consistent with what the student conceives to be right, good, and well-considered action.

With respect to skills, habits, and abilities, the case is different: these educational outcomes contain objective elements which all competent people will agree may reasonably be sought for in all students, and their development can be objectively observed and recorded. Hence, the teacher is in

a position to be more definite in his aims and expectations regarding them.

Tentative List of Generalizations Bearing on Major Generalization C

1. Metals derived from the earth's crust are very important materials for industry.
   a. The extensive use of iron is due to the distribution of its ores, the ease of its extraction, and its useful physical properties.
   b. The location of plants for the production of iron and other metals is generally determined by the relationship between accessible sources of ore, flux, and coal, on the one hand, and the distance to markets on the other hand.
   c. The protection of iron and other metals against rust and corrosion requires the work of certain large industries and the expenditure of large resources.
2. Non-metallic materials (such as clay, sand, feldspar, asbestos, sulphur, limestone, and rock phosphate) derived from the earth's crust are essential for ceramic, glass, cement, building, fertilizer, and other major industries.
3. Materials obtained from the sea, such as salt, bromine, and chlorine, are essential in modern industry.
4. Nitrogen, argon, and neon, obtained from the atmosphere, are important in modern industry.
5. Materials (such as rubber, cellulose, starch, and sugar) derived from plants are basic to great industries.
6. Plant and animal life is dependent upon certain substances in the soil and atmosphere.
   a. Rotation of crops and use of fertilizers conserve the soil materials and energy necessary for plant life.

Illustrations of Possible Student Activities

(Pertinent bibliographical material and films are listed at the end of this chapter, page 299.)

Experiments

1. How can iron be obtained from its oxide ores? (Have the student obtain iron by passing hydrogen over heated iron oxide.

Let him plan the experiment, perform it, and prove that he has iron.)

2. What other metals can be obtained by the reduction of their oxide ores? Obtain other metals by reducing their oxide ores with carbon or aluminum.

3. What are some of the causes of the corrosion of iron?

a. Test the action of iron with hydrochloric acid, and compare with that of copper. Are there other metals which behave like copper in this respect?

b. What is the action of moist air on iron? Shake iron filings in a wet test-tube until the inner walls are nearly covered with them. Invert the test-tube over water so that the mouth is well under the surface. Allow to stand for a day or so, noting at frequent intervals any change in the volume of the air and in the appearance of the filings. Repeat the experiment, using: (1) fine copper or brass filings, (2) a mixture of iron and copper filings. Also place dry iron filings in a watch glass and expose them to the air for the same length of time, noting any change in appearance. Compare results of the two experiments.

c. What changes occur in iron pipes, nails, etc., when they undergo marked corrosion? Examine iron nails, pipes, etc., which are badly corroded.

d. How does the etched surface of iron and steel look under the microscope? Etch specimens of cast iron and steel with acid, and examine the surfaces with a compound microscope, using an epi-mirror to improve illumination.

e. Look up the factors involved in the corrosion of iron products, and determine how the different methods of protecting them against corrosion take these factors into account.

4. Make a collection of samples of ores of various metals.

Library and Map Work

1. What metals were used by the ancients? How were these metals obtained? How many metals were known in 1775? How many are used today?

2. What metals are used in an automobile?

a. Locate on an outline map of the world the more important deposits of each of these metals.

b. Look up the methods by which they are extracted from their ores.

c. What alloys are used, and what advantages do they offer?

d. Can all the metals necessary for making an automobile be found in the United States?

3. Locate on an outline map: (*a*) the more important iron ore deposits of the United States, (*b*) the more important coking coal deposits.

4. Indicate on the same or a similar map the location of the more important blast furnace plants of the United States Steel Corporation. How are these locations related to those of 3(*a*) and (*b*) above?

5. Trace on a map the routes which the raw materials—limestone, coke, and ore—follow on their way to a steel plant in this country.

6. Study the manufacture of iron from ore, describing briefly the processes that take place in the blast furnace.

7. Treat in like fashion the manufacture of open-hearth steel.

8. It is sometimes said of the metallurgy of iron that "the ore always comes to meet the coal." Why?

9. In view of the statement above and of the industrial importance of coal and iron, give one reason for the century-old struggle of Germany and France for the possession of Alsace-Lorraine and for the seizure of Manchuria by Japan. Show how the "mountain of iron" in Austria is one of the chief reasons for rivalry between Germany and Italy for political control of Austria.

10. Look up the methods involved in making Bessemer steel and electric steel. Why is use of the former process decreasing while use of the latter increases yearly?

11. Study the development of modern alloy steels and the implications of their resistance to corrosion for modern society. They have, for example, provided new and valuable materials and increased employment in the process of developing new products. But in the form of carboloy lathe tools they have increased either unemployment or leisure—which?

12. What hazards exist in a steel plant? Pneumonia, for example, is all too common among the workers because of the sharp changes in temperature to which they are subjected. What can be done to lessen these hazards?

13. What cities of the United States owe their location and development to the iron and steel industry? What factors beside bringing together raw materials determine the location of a "steel" city? Illustrate with Gary, Indiana.

14. Similar studies might be made of aluminum and its alloys.

Excursions

Though no mention of specific excursions is made here or in some subsequent sections, it is assumed that the student will have opportunities to make such excursions and to confer with representatives of industries and other experts in studying topics in these areas.

D. Application of the Sciences Increases Control over Energy and Materials

The science teacher can make no more important contribution to an understanding of modern economic life than that represented by a knowledge of the way in which machines put energy derived from inanimate sources at the disposal of men. In ancient Athens the average free citizen seldom had more than two or three slaves at his disposal. In the United States in 1935 machines were providing 1,231 million horse-power, or about ten horse-power per capita, the energy equivalent of about one hundred slaves.[7] The modern individual commands mechanized energy in the automobile he drives, in the washing machine or vacuum cleaner he starts with the turn of a switch, in the apparatus he operates in the course of his job. This increase in the amount of energy at the disposal of the individual has been brought about through the applications of the sciences.

In arriving at this understanding, the student should be led to consider the issues involved in the distribution of control over this energy among different economic groups. Obviously wealthy people control an energy equivalent of thousands of slaves whereas poor people have little more than

[7] *Technological Trends and National Policy Including the Social Implications of New Inventions, op. cit.,* pp. 249, 252.

the energy of their own muscles at their disposal. In discussing solutions of this problem of distribution, questions like the following should be considered: "How is the power of control over energy actually distributed?" "Would some other kind of distribution be preferable?" "What are the social consequences of existing forms of control, and what would be the social consequences of alternative forms?"

At the same time the following questions should be raised: "To what degree does a proposed solution recognize the optimal development of personality?" "Does it take into account the democratic way of settling issues—conference and discussion, decision based upon the exercise of intelligence?" Furthermore, young people should learn to use democratic ideals as criteria for evaluating their own use of the energy they control. Are the results of their use of automobiles and other means of transportation, for example, socially good or socially bad? They will be socially good only to the degree that the students realize the possible effects of their conduct upon the welfare of others and subject their use of energy to the discipline of social responsibility.

It is not only energy that the sciences have put at man's disposal in amounts undreamed of in former centuries; they have also provided the means of technical control over a variety of metals and other materials that transcends the dreams of alchemists. And through knowledge of scientific principles of growth and breeding they have provided the means of control over plant life that makes it possible not only to produce new varieties of fruits and grains but to double and triple the yield per acre, and they have made possible similar control over the breeds and productivity of food animals.

In 1787, the year the Constitution was framed, the surplus food produced by 19 farmers went to feed one city person. In recent average years 19 people on farms have produced enough food for 56 non-farm people, plus 10 living abroad. Productivity per farm worker increased steadily, and at very nearly the same rate in agri-

culture as in industry during the 75 years after 1850. Between 1910 and 1930, output per worker increased 39 per cent in manufacturing and 41 per cent in agriculture.[8]

The technological advances which underlie the astounding increase in the amount of energy and material available for use are the results of intelligent application of scientific knowledge to human affairs. Inventions are the fruit of man's capacity to use intelligence creatively. Students should be led to consider whether advances similar to those made by applying intelligence to technical problems could be made in the solution of social problems, were it possible to extend the range of application of the methods exemplified in the sciences.

The student should also come to recognize the rôle of scientific research in extending control over energy and materials. Developments in chemistry are making man more and more independent of natural syntheses. The use of catalysts, the development of modern alloys, the utilization of waste or by-products, all so important in modern industry, are the results of research. The National Resources Committee points out that since the beginning of the present century scientific research has given rise to six great industries (telephone, automobile, airplane, motion picture, rayon, and radio) which represent great accumulations of capital and give employment to millions. The number and extent of the social influences of these developments are impossible to calculate.

Particularly important is the idea that scientific research pursued without thought of immediate utility usually proves of immense practical value. But lest students come to think of pure science only as the benefactor of technology, it is important to help them see that pure science is also dependent upon technological resources and that many of the

[8] *Ibid.*, p. 99.

problems investigated by research in the pure sciences have their origin in the technological field.

In pointing out the effects of scientific research upon civilization, it is not enough for the science teacher to show that the results of research may be applied in ways both beneficial and injurious to society. He should lead his students to think of methods by which harmful applications may be obviated. Should society, through the government or some other social agency (consumers' organizations, labor unions, anti-war societies), exercise a measure of control over the uses to which the discoveries of the research scientist are put, the ends they are made to serve? If not, what are the controls that may rightfully operate in a democratic society to insure the use of these discoveries for socially desirable ends? The teacher should stimulate his students to evaluate the general results of research on the basis of all the human values involved and to develop in them a desire to apply ethical controls to the uses made of the sciences and their applications.

Tentative List of Generalizations and Inquiries Bearing on Major Generalization D

1. Application of the sciences has so increased the number of available materials and devices for controlling and using energy as to make the civilization of the present industrial age profoundly different from that of any earlier era.
   a. The development of machines which use energy from inanimate sources provides modern society with an enormously greater amount of power per capita than was ever before available.
   b. The modern age exceeds all others in the variety of metals and other materials at its disposal.
   c. Application of the sciences in large-scale projects can so alter the physical characteristics of a country as to change the character of much of its industry.
   d. Has application of the sciences resulted in an over-production of human necessities?

2. Application of the sciences to agriculture has increased man's control over plant and animal life.
   a. Improvement in the quality and increase in the quantity of the products of plant and animal husbandry are being effected through the application of scientific principles of breeding.
   b. New forms of agriculture may sometimes be established in a locality through the aid of such scientific techniques as acclimating insects which fertilize the blossoms of a plant or developing controls for certain insect pests.
   c. Do present conditions in agriculture permit a reasonably full utilization of scientific knowledge?
3. Application of scientific knowledge to weather forecasting is important to navigation, aviation, and agriculture.
4. Scientific research continually extends man's control of energy and materials.
   a. Improvements in engines have enabled man to get increased amounts of useful work out of a given amount of available energy.
   b. Developments in chemistry are making man more and more independent of natural syntheses.
   c. When the need for a new substance is clearly defined, ways of producing it are frequently found, and when a new substance is produced, ways of using it are usually developed.
   d. The use of catalysts is changing some industrial processes and is making possible an increase in the yield and in the variety of available products.
   e. As in the past, the extension of the use of metals depends upon the development of more efficient methods of extracting them from their ores.
   f. Modern alloys play an increasing part in the development of new articles of commerce and of improved means of transportation and communication.
   g. Knowledge of the structure of solid substances gained through x-ray crystal analysis makes possible the more effective use of metals, alloys, and other substances.
   h. Utilization or sale of waste products or by-products has become essential to the success of some industries.
   i. The extension of one field of research usually opens up fields

which are essentially new and results in further discoveries.

j. Scientific research pursued with no thought of utility often turns out to be of great practical value.

k. Is there a relation between intensive research in a single field and the views of the research worker on economic life as a whole?

l. What determines the demand for trained scientists and technicians?

5. Increased control of energy and materials favors the development of scientific research.

Illustrations of Possible Student Activities

(Pertinent bibliographical material and films are listed at the end of this chapter, page 300.)

1. Determine the rate at which you or your friends are able to do work, that is, your power rating. It is said that the wealthiest Roman nobleman had 4,000 slaves. How much power did he command? Are there many men today who command as much? How much power do you control? What is the average per capita control of power in the United States at the present time? (See *Technological Trends and National Policy,* pp. 249–252.)

2. Make a list of at least twenty-five different materials in common use today which were unknown in this country in colonial days.

3. Compare the medical practice of George Washington's time with that of the present time. What particular things account for the difference?

4. Make a special study of the way the Russians have industrialized regions of their country which in the past were devoted exclusively to agriculture. What basic factors handicap the development of heavy industry in Russia?

5. Look up the method by which the sugar beet, which originally yielded only 4 per cent of sugar, was "bred" to yield at least 16 per cent. How is this same idea applied to producing strains of cows that give larger volumes of milk? Richer milk? What general methods were used by Burbank in developing new species of plants? Improving old ones?

6. In accordance with present farm chemurgy the soy bean is being raised in many states to supplement or displace other crops.

Give a half-dozen reasons for this. What other relatively new crops are used to vary and improve the output of American farms?

7. In what ways does weather forecasting greatly benefit navigation, aviation, and agriculture at the present time?

8. Below is a list of catalytic triumphs. Make it more complete by adding, if possible, the names of the catalysts in those places marked "not revealed." Also add to the list. What factors other than catalysts are necessary to the success of these processes?

Conversion	*Process*	*Catalyst*
1. Ammonia from atmospheric nitrogen	Haber process—nitrogen fixation	Iron
2. Nitric acid from ammonia	Ostwald process	Platinum
3. Sulphur trioxide from sulphur dioxide	Contact process for sulphuric acid	Platinum
4. Alcohol from sugar	Industrial alcohol fermentation	Zymase (from yeast)
5. Butyl alcohol and acetone from starch		Weizmann bacteria
6. Sugar from starch		Diastase
7. Crisco from cottonseed oil	Wesson hydrogenation	Nickel
8. Methyl (wood) alcohol from water gas		Zinc oxide
9. Acetic acid from acetylene		Mercuric and manganese salts
10. Phthalic acid from naphthalene (moth balls)		Mercury
11. Gasoline from coal	Bergius hydrogenation	Not revealed
12. Ethylene from acetylene		Not revealed
13. Carbon tetrachloride from carbon disulphide		Ferric chloride
14. Indigo from naphthalene (moth balls)		Nickel
15. Hydrogenation of petroleum		Oxides of iron, vanadium, chromium, and molybdenum
16. Sugar from cottonseed hulls		Not revealed
17. Rubber from acetylene		Not revealed

9. It is said that within fifteen years artificial rubber will displace natural rubber. What factors tend to interfere with such an economic transition?

10. When the development of the "French" type of instrument was being considered by the telephone company, the need for an improved form of permanent magnet steel was recognized. What was the result of the research this initiated? What similar instances can you cite from the history of American industrial research (that is, where the demand for a substance resulted in the discovery of a way to supply it)? Cite at least one case where the discovery of a new substance led to finding ways of using it.

11. What use is made of alloys in the modern motor car? Make a skeleton diagram of a modern car. Label it, showing the location of each of the more important alloys used in its construction. What is the use of each? What alloys are used in other forms of modern transportation? In stratosphere flights?

12. What alloys were used in ancient times? In 1775? Make a list of the more important alloys used today.

13. Find several instances in which the success of a modern industry is conditioned by the utilization or sale of by-products.

14. Find several instances where the results of research pursued without any thought of utility have proved of great practical value.

15. What are some of the major technological possibilities that may soon be realized? Rocket ships? Molecular turbines?

16. Consult a research physicist of an institution like the Bell Telephone Laboratories in regard to the extent to which specialization is carried out in modern research. What effects might a high degree of specialization have on the research worker? Do research workers have any control over the uses that are made of their discoveries?

17. Find examples of scientific research made possible through technological improvements (for example, research with x-rays, molecular beams, neutrons, etc. which has been made possible through improved methods of producing a vacuum, electricity, or high voltages).

18. Study and report on (*a*) the so-called "tray agriculture" whereby amazing crops of tomatoes can be grown in shallow pans of water containing nutrient chemicals, and (*b*) the sand culture

whereby the same sand can be used repeatedly to produce large yields, if the proper nutrients are supplied each time a crop is grown.

E. Social and Economic Conditions Depend in Part upon the Distribution, Use, and Control of Energy and Materials

In the course of the preceding pages it has been repeatedly noted that the science teacher must do more than help his students understand that modern society depends upon the use and control of energy and materials for the conduct of technological operations and that the applications of the sciences provide increased control of energy and materials. He should also help them to see and evaluate the effects of the applications of the sciences on social and economic conditions.

In so far as the science teacher is concerned with training citizens who will act for the common good on the basis of their understanding of the economic consequences of the sciences, he can follow one of two courses. He can either devote a part of his program to the study of some of these consequences usually conceived to lie in the field of the social studies, or he can work closely with a social-studies teacher who attempts to help students develop social sensitivity through the understandings they gain from study of the natural sciences. The task of helping students to understand social consequences is not the responsibility of the science teacher alone; he should almost never proceed without cooperation with the teacher of social studies. This procedure should insure against the teaching of technology and its economic effects being divorced from the ethical questions involved: the student should come to see that though a scientific process is neither moral nor immoral, but unmoral, yet its application may have good or bad effects upon society, that this potentiality for good or evil lies in the plans and purposes of the individuals who use it, and that this use should be subject to control for the sake of the common good.

The science teacher may lead the student to see that the availability of various metals and the use made of them determines the nature not only of technological operations but of many social institutions which technology affects. Even more important is the understanding that since the Middle Ages the material basis and cultural forms of western civilization have been profoundly modified by the introduction of machines and other technological developments. Moral ideas have been influenced not only by various elements of the scientific world picture, such as the concepts of a heliocentric solar system and of biological evolution, but also by such technical developments as motion pictures, radios, automobiles, antiseptics, contraceptives, and anesthetics. The more people have confidently expected a high standard of living in this world, the less have they found consolation for the poverty of their lot in the hope of an after-life of heavenly bliss. Modern society is essentially secular in outlook; for the medieval view of life as a miserable stepping stone to the hereafter, it tends to substitute the endeavor to make life more beautiful and satisfactory on this earth.

The student should see how the standards and tempo of living have been and are being modified by the application of the sciences. The change in man's economy of food production from one of scarcity to one of potential abundance should be pointed out as a result of the application of controlled energy to production. Refrigeration, air-conditioning, radios, films, automobiles have raised living standards. In this connection the student may consider the effects of modern technological devices on the enjoyment of leisure.

Also significant, to the American especially, are the changes these devices have made in the tempo of living. For centuries the human race has adapted its tempo to that of nature—climate, seasons, daylight, and dark. The cycle of the day and of the harvest, the variations in heat and cold, have set the pace of life. Industrial society lives at a man-made tempo, ignoring the rhythms of nature—it works and plays either by

day or by night in heated, lighted, air-conditioned buildings, with regularity or irregularity, in fair weather or foul. It provides a way of life which in large measure substitutes the caprice or the conscious organization of man for the discarded patterns of nature.

Although some of these changes are of questionable value, and the student should be encouraged to be critical of them, it is important also that he see the possibilities of making human living more satisfactory through social planning to control the resources potentially at man's disposal. Through rational planning and effective social organization man can choose which results should be realized out of the many possibilities offered by invention and technology.[9]

Consideration should be given to both the desirable and the undesirable aspects of the part that machine technology has played—through increased division of labor and mass production—in bringing about present economic conditions. It has increased quantities of goods, lowered prices, and increased leisure; technological unemployment, monotonous employment, uniformity of products, industrial hazards are its tolls.

The science teacher concerned with helping his students develop social sensitivity should include such subjects as the following in his own preparation and reading and in the science program: the distribution of industrial income among workers, owners, and management; the relations between labor unions and employers, munitions industry and international conflict, unemployment and specialization of labor; occupational diseases, dangerous trades, nerve-wracking machinery; housing conditions in industrial areas and company towns.

Modern industry is carried on by mass activity, specialization of function, and a high degree of integration. The worker often is tied to a machine or organization and is de-

[9] *Ibid.*, pp. 12, 13, 24, 261.

pendent on the functioning of the whole social and economic system for the chance to work and live. The majority of individuals in the western world work in conjunction with many others—inserting a set of bolts as the automobile frame travels down the belt; delivering a letter or taking a ticket; gathering the news or mending a telephone wire in a complex system of communication; analyzing milk or experimenting with a vaccine in the wideflung coöperative attack on disease; running a corner grocery, selling goods from behind a department-store counter, editing a mail order catalogue in the complex system of distribution; patrolling a highway or presiding over a court. Each individual performs a function that is closely interlocked with that of others and that cannot be performed if the mechanism of which it is a part breaks down.

Applications of the sciences have not only increased this kind of human interdependence but have unified the world by new and faster means of communication, transportation, and the exchange of goods. Interdependence now extends among different occupations, regions, and nations. Together with the forces that threaten the mutual coöperation it requires—war and economic nationalism—this interdependence raises the question of whether new institutional forms are necessary to make political and economic coöperation effective under changed conditions.

An increased measure of associational living, together with the advantages derived from specialization and mass production can probably be brought about only through controls and restrictions upon individual action. Unless young people grow up with attitudes of coöperativeness, recognizing the fact of interdependence and the necessity of associational living, there is reason to believe that they and the world they live in will be forced to surrender many of the privileges and benefits that technology and the application of scientific knowledge are making possible.

The science teacher can use his subject-matter in several ways to foster attitudes of coöperativeness in his students. He can help them to see the necessity of coöperation and associational living in the modern world through developing understanding of some of the generalizations listed in this chapter. He can show them how the sciences themselves offer striking evidence of coöperation. A science, they can see, is seldom nationalistic or race conscious; it is the product of the collective activity of men who are widely separated in space and time, linked in many cases only by their common interests and attempts to understand and control nature. Even the geniuses of science have depended upon their fellow-workers—Newton himself said, "If I have seen a little farther than others, it is because I have stood on the shoulders of giants." The increasingly rapid progress of science in modern times may be attributed to coöperative attack by many men upon more difficult and complicated problems; to no small extent it has been due to the fact that scientists publish their work widely and look for help from other scientists throughout the world.

The teacher should help students to see how banding together for the achievement of common purpose—whether in scientific societies, political parties, chambers of commerce, labor unions, or student organizations—furnishes the means for coöperative action, and to recognize how necessary are such characteristics as tolerance, patience, and generosity on the part of individuals who work together and coöperate in this way.

Tentative List of Generalizations and Inquiries Bearing on Major Generalization E

1. The character of a civilization is determined in large part by the availability and use of various metals.
2. During the last thousand years the material basis and cultural forms of western civilization have been profoundly modified by the development of the machine.

a. Man's moral ideas have influenced and been influenced by technical inventions and processes.

b. Man's increasing concern with the high material standard of living made possible by the application of science is related to his changing attitude toward some aspects of religion.

3. Improvements in methods of utilizing materials and of controlling natural sources of energy result in raising the standard and changing the tempo of living.

a. Man's economy of food production has changed from one of scarcity to one of potential abundance through the application of controlled energy to production.

b. The production of artificial climate by refrigeration and air-conditioning has become essential to the food supply and is an increasing factor in the comfort of modern civilization.

c. The discovery and exploitation of new resources usually lead to an expansion of industry which tends to raise the standard of living, and this, in turn, may stimulate an increase in the population.

d. Radiant energy of extremely varied wave-lengths is serving the therapeutic, esthetic, and recreational needs of modern society.

e. Modern science has produced many devices which make possible a greater enjoyment of leisure.

f. Has science tended to make enjoyment of leisure too passive?

g. How has the application of science helped to raise the standard of living?

4. Machine technology creates new economic and social conditions.

a. The use of science in practical activities has increased specialization and the division of labor, and has made mass production possible.

b. With its division of labor, modern technology tends to reduce the tasks of increasing numbers of individuals to simple repetitious processes, which are often excessively monotonous.

c. While technological advance in the prevailing economic framework often deprives people of employment in one area, it also provides opportunities for new employment in another, but seldom to the same people.

d. Modern industry introduces new hazards which may require special precautions.

e. Machine technology promises greatly to increase the amount of leisure possible for all.

f. Mass production promises to supply increasing quantities of desirable goods at lower costs.

g. Mass production makes it necessary for most people to accept uniform grades and styles of goods and services, including amusements, reading matter, transportation, and housing.

h. To what extent should society control its scientific specialists and experts?

i. What can be done to lessen the strain on people whose work consists of monotonous and repetitious processes?

j. Can science or technology be said to be responsible for economic depressions?

k. What influences do economic forces have upon the development of science?

l. How does the application of science in America differ from that in other countries?

5. The development of rapid transportation and communication has increased the variety and quantity of materials available at any one place and has brought about the economic interdependence of different geographical areas.

a. The necessities of civilized life come from producers in widely different regions who are only remotely connected with the consumers they serve.

b. Does the present economic interdependence of people require the development of new and more effective forms of economic and political coöperation?

c. Should nations attempt to become economically self-sufficient through the development of new methods of producing the goods they now import from abroad?

Illustrations of Possible Student Activities

(Pertinent bibliographical material and films are listed at the end of this chapter, page 302.)

1. Study the present status of the following inventions said by the National Resources Committee to promise the most important

social influences. Try to predict their future development and social consequences.

The mechanical cotton picker, air-conditioning equipment, plastics, the photo-electric cell, artificial cotton and woolen-like fibres made from cellulose, synthetic rubber, prefabricated houses, television, facsimile transmission, the automobile trailer, gasoline produced from coal, steep-flight aircraft planes, and tray agriculture

2. Compare the condition of your family with that of a king and of a common man of the Middle Ages in regard to:

a. Variety, quality, and purity of available foods
b. Comforts of home living
c. Facilities for communication
d. Methods of transportation
e. Medical service available
f. Facilities for enjoyment of leisure
g. Complexity of life and tempo of living

How do you account for the differences?

3. Write an account of what you think the modern world would be like if:

a. There were no iron or steel (or its equivalent in qualities and abundance).
b. There were no modern machines or engines.
(Read the story of the bronze or stone age in *Our Prehistoric Ancestors,* by H. F. Cleland)

4. What problems faced by modern industrial society were unknown in the days of Caesar or of Homer? What can we do to help solve these problems?

5. What new economic and social conditions have been created by machine technology?

6. What are the effects of electricity in present-day society?

7. What have been the effects of rapid transportation and communication on modern society? Has it made different geographical areas more interdependent economically? Has it made different people more coöperative? Should a nation "live unto itself," that is, attempt to become economically self-sufficient?

8. Is the factory worker better off today than he was one hundred years ago? Is the farmer?

9. What working conditions prevail in a modern steel plant? Do

the workmen have any share in determining these conditions? What, in general, are the relations between employer and employee? Are any particular racial groups primarily employed?

10. With the complexity and specialization of modern society can the average citizen possibly know the facts about all the articles he uses? Does this indicate the need of experts to protect his interests?

11. What kind of control should the government exercise over industry?

12. What has been the effect of modern technology on the methods and probable consequences of warfare? Has it tended to lessen the likelihood of war? Should the government own the munitions plants?

13. Study the motives behind the colonization programs of France, England, Italy, and Germany. Have metals and other raw materials been involved?

14. Has machine technology provided increased amounts of leisure for most people? Would you criticize the present-day use of leisure?

15. In what ways is radiant energy of various wave-lengths serving the needs of modern society?

Excursions

In making excursions to various industrial plants the student should observe not only the scientific processes but such factors as working conditions and industrial hazards. Students should also attempt to discover the attitudes of employees of various kinds toward their work. To these ends it is desirable to have the class eat luncheon in the workers' dining room.

F. Conservation of Exhaustible Natural Resources Is a Social Responsibility

Social responsibility for the conservation of natural resources should be a recurring theme throughout the study of the use and control of energy and materials, and of man's dependence upon the environment for them. It has been pointed out (in Chapter II) that for the sake of the broader

good the socially sensitive person is willing to take measures counter to his own immediate comfort or that of the group with which he is identified, and it may be necessary to call upon many individuals to take such measures if natural resources are to be conserved for future generations. Some students may eventually vote on questions concerning the right of certain groups of which they themselves are members to control and exploit natural resources. The real problem of conservation is that of finding a principle on the basis of which decisions about the use of resources may be made with intelligent regard for all the interests involved.

Though it is important to show that it is only through use —or misuse—of the sciences that men use up fuel and soil more rapidly than they are replenished by natural processes, it is also essential to bring out the positive values of science as an aid in the conservation of natural resources. Modern methods of agriculture can safeguard the fertility of soil. Newly developed synthetic processes use raw materials which are inexhaustible. Scientific forestry can be used to assure a constant lumber supply and to prevent erosion and floods. Huge conservation dams contribute to agriculture in drought-afflicted regions. Increasing efficiency of fuel-burning engines tends to conserve coal and oil. There is also the probability that the discoveries of science may provide new supplies of energy and materials to augment those now available. It is important that young people not develop too parsimonious an attitude toward the world's resources and that they sense the immensity of the resources made available by the advance of science.

Tentative List of Generalizations and Inquiries Bearing on Major Generalization F

1. Application of the sciences has enabled man to use up natural resources of fuel and soil more rapidly than they are replenished by natural processes.

2. The dispersion of material which results when metal objects are discarded or revert to rust renders quantities of metals unavailable to future generations.
3. Agriculture may be carried on by methods which conserve the fertility of the soil.
4. The development of synthetic processes using inexhaustible raw materials is an aid to conservation of natural resources.
5. Scientific forestry is being used increasingly to assure a permanent lumber supply and to prevent erosion and floods.
6. The building of dikes, levees, and artificial storage lakes along certain large rivers has been undertaken in many countries to provide flood control and protection against drought.
7. Increasing efficiency in the utilization of fuels and other materials tends to conserve natural resources.
8. In the future industry may have to secure most of its energy from sources other than coal and petroleum.
9. Can the discoveries of science be expected to provide new supplies of energy and materials to augment those now available from natural resources?

Illustrations of Possible Student Activities

(Pertinent bibliographical material and films are listed at the end of this chapter, page 304.)

1. In what ways is modern society wasting its natural resources? Suggest some general methods of reducing these wastes.

2. Show how modern photography is responsible for the loss of enormous quantities of silver. Show how the final disposal of most articles made of iron results in a similar loss of immense quantities of iron.

3. It is said that as a result of superior methods of agriculture many of the farms of Pennsylvania are in better condition today than they were one hundred and fifty years ago. How has this been accomplished?

4. In certain sections of the West, large-scale farming was carried on until the soil was "worn out." Then the farmer moved to a new area and repeated the process. Explain. How could this loss have been avoided?

5. What are the chief causes of the conditions in the western

"Dust Bowl"? Make a special study of the government program for improving these conditions. Must large areas formerly given over to farming be seeded with special kinds of grass and returned to prairie for grazing purposes?

6. What general methods are being used to prevent loss of soil through erosion?

7. In what three important ways can a scientific reforestation program serve to safeguard the natural resources of the country? What can you do to assist in forest conservation?

8. What is being done by the government to conserve a water supply for drought-afflicted regions?

9. What relation does the use of water power bear to the conservation of other natural resources?

10. How long will the country's present resources in coal and oil last? What energy sources will take their place? How can this coal and oil supply be made to last longer?

11. In what way may coal be used to insure an oil supply in the future?

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(For details on sources and annotations, see note under "Films" on page 293.)

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Metals of a Motor Car (30 min.), 16 mm.; silent; loan (1933, Bureau of Mines).
Four Men and the Soy (two reels), 16 mm.; silent; loan (1925, U. S. Department of Agriculture).
It Might Have Been You (one reel), 16 mm.; silent; loan (1933, U. S. Department of Agriculture).
Dairy Cattle and Their Selection (15 min.), 16 mm.; silent; $24 (1921, Society for Visual Education).
When the Cows Come Home (one reel), 16 mm.; silent; sound; loan (1932, U. S. Department of Agriculture).
From Mountain to Cement Sack (15 min.), 16 mm.; silent; loan (prior 1927, Bureau of Mines).
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Chemical Ethyl Alcohol (15 min.), 16 mm.; silent; rent; $3 (1932, De-Frenes).
Story of Bakelite Resinoid (30 min.), 16 mm.; silent; loan (1928, Wholesome Film Service).
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MOYER, J. A., and FITTZ, R. U., *Air Conditioning* (New York, McGraw-Hill Book Co., 1933).

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(For details on sources and annotations, see note under "Films" on page 293.)

Land Transportation (15 min.), 16 mm.; silent; $25 (1929, Harvard).
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Electricity on the Farm (20 min.), 16 mm.; silent; loan (1935, T. V. A.).
Commerce Around the Coffee Cup (11 min.), 16 mm.; sound; loan (1935, U. S. Department of Commerce).
Communication News and Views #1 (11 min.), 16 mm.; sound; loan (Bell Telephone Co. of Pa.).
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Anchored Acres (one reel), 16 mm.; silent; loan (1923, U. S. Department of Agriculture).
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Chaparral (two reels), 16 mm.; silent; loan (1935, U. S. Department of Agriculture).

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VII

TEACHING SCIENCE IN WAYS TO ENCOURAGE REFLECTIVE THINKING

INTRODUCTION

The disposition and ability to do reflective thinking is one of a number of outcomes of educational experience stressed in the preceding chapters of this book. It is singled out for further treatment in this chapter because of the special interest in and emphasis on reflective thinking which have long characterized science education.

The Committee believes that the ability to think reflectively and the disposition to do so in all the problem situations of life is an especially important educational objective. It is essential to adaptability, resourcefulness, and that type of self-criticism or "stock-taking" which leads to the continuing re-evaluation of personal beliefs and principles of action. The Committee also believes that science may be taught in ways to encourage reflective thinking.

Today there is great need for adaptability and resourcefulness in extending and applying knowledge. Not only are the conditions under which people live undergoing rapid transformation, but the whole structure of society is changing in quite fundamental ways. Some people regret these changes and would prefer to be living in a less rapidly changing world in which they could follow more closely in the steps of their fathers. But the choice is not open to them. They must adapt themselves to changing conditions whether they will or no. The only choice that is open to them is between being carried along by events, regretful for the past, and deliberately moving with events and learning to direct them intelligently, with

confidence that the future may be made better than the past. This latter course is only possible for people who are studying the changes that are taking place in the world and are applying their experience imaginatively to the changing situation. It should be part of the aim of science teaching to encourage the reflective thinking upon which adaptability, resourcefulness, and self-criticism depend.

But the Committee's position on the way in which science teaching may encourage reflective thinking differs sharply from the two positions which have been most commonly taken in regard to the value of science teaching in this connection. One of these positions is based on the doctrine of "mental discipline"—the assumption that resourcefulness of mind, or the ability to bring previous experience to bear on new situations, can be trained through exercise in such logical disciplines as are provided by the ancient languages and mathematics. Under the influence of this belief the sciences have been taught deductively and with emphasis on their logical organization with a view to training in an ability which, it was assumed, would "transfer" or come into play in quite different kinds of problems. The other position denies the practical effectiveness of this procedure and assumes that students must be given specific training for the specific situations in which they are likely to find themselves—that if students are to buy automobiles and radios wisely in later life, they must be taught specifically how to do just these particular things at school.

The Committee believes that neither of these ways of teaching science has been effective in encouraging reflective thinking and its outcomes in resourcefulness, adaptability, and self-criticism. It believes that young people will be helped to achieve these ways of thinking and acting only by wide successful experience in attacking and surmounting the problems with which novel situations confront them and in adjusting themselves accordingly, and that this adaptability, resourcefulness, and self-criticism will be exhibited mainly in situa-

tions similar to those of which they have had previous experience. Further, the Committee believes that these must be situations in which young people meet their needs and thus have their interest aroused, and that reflective thinking will be made more effective if this experience is fortified in later adolescence by a conscious awareness of the processes in reflective thinking.

THE NATURE OF REFLECTIVE THINKING

When Reflective Thinking Appears in Characteristic Form

Reflective thinking is that kind of thinking which may appear when a problem arises that finds no ready solution. At the most practical level the problems that give rise to reflective thinking are immediate problems of action. A man is confronted with an unfamiliar situation. His established modes of response are no longer applicable, and he must bring his past experience (including what he knows through having been told or having read) to bear in arriving at a new mode of response. The man can never be sure that the new response he adopts will succeed; any action is to some extent an act of faith; any course may fail.

Reflective thinking appears in its most characteristic form when the individual is confronted with a problem of a kind which allows and demands that overt action be suspended while the problem is thought out. Some such problems may be solved after a relatively short period of suspense. Others involve protracted reflection; sometimes, when the solution is very eagerly sought, it may lead to such preoccupation as to cause sleepless nights and inability to concentrate on anything else.

Many problems of the scientist find a more satisfactory solution if action is deferred until the situations in which they arose are explored for relevant facts and principles and promising suggestions. If a chemist, for example, has before him the problem of making a lubricant for use between metal pieces which move against each other with enormous pressure,

he may set the particular and immediate problem aside and study the behavior of monomolecular films of oil. By attacking this more "theoretical" problem he may arrive at an understanding of the structure and properties of oil films which will enable him to predict that a certain substance will make a good lubricant for use in the situation that gave rise to the problem which, in its particular form, he had temporarily set aside.

Many problems not in the field of the natural scientist are best attacked in similar fashion. For example, if a citizen is faced with the problem of deciding how to vote on the question whether the local government should develop and sell electric power in competition with private companies, he would do well to suspend his decision while he defined the problem for himself in something like the following terms: What, in the history of utility-rate legislation, supports the claim that a government "yardstick" is needed? What advantages and disadvantages would result for power consumers, employees of the private utility company, holders of stocks and bonds of the private company, taxpayers, if the city were to establish a power plant? Having found answers to these questions, he might be in a better position to make up his mind how to vote in terms of his own particular values and "philosophy." It is of great importance for young people to have experience in suspending judgment and action while they think out their problems.[1]

The Process of Reflective Thinking

The process of reflective thinking may be analyzed into the following five phases:

1. *A sense of perplexity, or of want, or of being thwarted, followed*

[1] For examples of teaching of botany and zoölogy in ways that emphasize the importance of the statement of problems and of other factors in reflective thinking, see chapters by Homer C. Sampson and William M. Barrows in *Service Studies in Higher Education,* edited by Ralph W. Tyler and others, Bureau of Educational Research, Monograph No. 15 (Columbus, Ohio, The Ohio State University, 1932).

by identification of the problem. This may or may not be formulated in words.

2. *"Occurrence" of tentative hypotheses.* These hypotheses may be based upon a supposed relationship between what is perplexing in the situation and what has been previously experienced.
3. *Testing and elaborating hypotheses,* by imaginary experiments, which may on some occasions be supplemented by recourse to paper and pencil experiments and on others to even more concrete practical experiments. This process may also require reference to books or other records.
4. *Devising more and more rigorous tests* to which the resulting hypotheses may be subjected. Testing the hypotheses in these situations either solves the problem or reveals that the hypotheses do not stand the test of action.
5. *Arriving at a satisfactory solution and acting upon it.* This may include devising a form of statement by means of which the conclusions may be expressed and communicated with the highest possible precision.

None of these phases of thought into which reflective thinking may be analyzed is really distinct. They all go on more or less simultaneously, each doing something to perfect the others. Thus the test of an hypothesis may serve as a starting point for new observations and may suggest further modifications of the hypothesis, and the final formulation of the conclusion is but the culmination of a process that has been developing throughout the process of reflection and experiment.

Moreover, the analysis is incomplete, first in that it leaves out of account the fact that reflective thinking may be furthered at many points by discussion with others who are able to throw light upon the problem, and second in that it focuses attention on only the conscious aspect of a process in which the whole organism participates.

To explain how tentative solutions or hypotheses arise is as difficult as to give an account of how almost forgotten things are recalled. Undoubtedly a great many unconscious factors enter into and influence the process. It is, moreover, an error to suggest (in so far as it makes sense to suggest it at all) that

a logical method "underlies" the process of reflective thinking. Though there is some justification for using the word *method* to describe the processes through which tentative solutions (or hypotheses) are put to the test (whether imaginatively or actually), it is very doubtful whether the process of casting around in past experience for possible solutions can be properly described as following a method at all.

Abilities and Attitudes Exhibited in the Process

In spite of the impossibility of describing all that goes on in the individual during the process of reflective thinking, and in spite of the difficulty of giving a complete account of even its conscious aspects, there is some value in attempting to identify the abilities and attitudes exhibited in the process. The values of such an analysis lie in the suggestions it affords for devising ways of teaching which may contribute to the development of the ability to do reflective thinking and ways of evaluating student growth in this ability.

The evident shortcomings of such a procedure are not so great as to outweigh its advantages. It is much as if playing tennis were to be analyzed into strokes, holds, foot positions, and combinations of these. Though no one would learn to play by practising these separately, yet one could improve his game by securing criticism of his strokes, hand holds, and so forth, and by practising so as to improve his weak points. And a critic would have to evaluate his improvement in terms of these various aspects of the game, which he knows from experience are important.

Therefore the following analysis of reflective thinking in terms of general and special abilities, and attitudes or dispositions is presented.

General and Special Abilities

a. To recognize clearly (in imagination, with or without statement in communicable form) what the problem is

b. To bring past experience effectively to bear in making preliminary guesses as to what is the crux of the problem, that is, in guessing upon what factor in the situation it is most efficient to concentrate
c. To recognize what things previously learned (whether from experience, or books, or both) may contribute to the solution of the problem
d. On this basis to form hypotheses that will serve as a basis for imaginary or practical experiment
e. To marshal evidence which either supports or invalidates any given hypothesis
f. To see (though not necessarily through any formal logical process) what are the crucial tests to which an hypothesis can be subjected
g. To devise experimental conditions or to find analogous situations which will test the hypothesis most conclusively
h. To express conclusions unambiguously

Here again these abilities must not be regarded as distinct; they are not formal entities apart from their context. They obviously stand in the very closest relationship to one another and to the situation in which they are used.

Some teachers have found the following list of more specific abilities, skills, and techniques helpful in encouraging young people to practice reflective thinking in science situations:

a. Skill in devising and setting up experimental apparatus
b. Skill in the use of measuring instruments
c. Skill in recognizing sources of error in observation and measurement
d. Skill in getting the sense of a written passage
e. Skill in using libraries and other sources of graphic information
f. Skill in assessing the reliability of authorities
g. Skill in expressing hypotheses and tentative conclusions unambiguously and economically in words or other symbols
h. Skill in mathematical procedures, including statistical methods and graphing

i. Skill in conducting discussion in ways to bring the main issues to the forefront

Attitudes or Dispositions

a. Active curiosity
b. Caution in making generalizations and readiness to revise them in the light of new evidence
c. Tolerance of new ideas and suggestions from all sources
d. Disposition to search out and try out a variety of approaches and points of view on a problem
e. Confidence that scientific methods will be successful in solving problems
f. Disposition to see a problem through to its conclusion in spite of distractions
g. Readiness to act on the basis of tentative judgments

HOW THE SCIENCE TEACHER MAY ENCOURAGE REFLECTIVE THINKING

Widening the Range of Problems Which Are Real and Stimulating to the Student

In the use of the word *problem* it is important to distinguish between problems which appeal to students' interests and those which a teacher propounds without reference to their interests, though he may say that students "ought" to be interested in them.

Further, what the teacher senses as a problem or is interested in may be of no interest to the student and no problem to him.

The problems of young people are closely related to the things they want to do, to have, to be, to gain mastery of. These problems have their origin in the curiosity of the young child, and they change and expand as the child develops in relation to his environment. Teachers can do a great deal to help students recognize new and challenging problems by setting up situations which extend the range of their interests and understandings.

Overcoming Obstacles to the Wide Use of Reflective Thinking

Some students will always show greater resourcefulness in thought and action than others, and there is undoubtedly an upper limit to each student's resourcefulness in each environment. Nevertheless, the teacher's behavior toward the class and toward individual students may have a very large influence in encouraging or discouraging development toward that limit. If he denies them the satisfaction of searching for the solution of a problem by providing them in advance with a solution that they might otherwise have reached for themselves, or if he is unsympathetic toward the mistakes they make in trying to think through problems for themselves, he may destroy their confidence and initiative and make them increasingly dependent upon authority. In all this he must remember that his influence is upon the character and feelings of his pupils rather than upon the development of their intellectual capacities (though the two must, of course, be recognized as most intimately related).

Obstacles to reflective thinking lie both in the personalities of individuals and in the social environment. There are emotions, prejudices, feelings of inferiority or insecurity, that may either impel a person to rush into hasty and ill-considered action or destroy his curiosity, numb his interests, and paralyze him for effective action. One of the ways to encourage reflective thinking is to help the student to become emotionally secure, so that he can feel safe in being actively curious, so that he is not afraid to act on the basis of tentative judgments, and so that he can tolerate new ideas and suggestions. In addition, the teacher should attempt to discover what the prejudices of his students are, how their minds are compartmentalized, what faulty mental habits they have, and he should plan his work so as to bring students themselves to scrutinize their own thinking in these terms. In certain cases he will find that by bringing students to criticize their own habits of thought he is undermining their emotional security, and in

such cases he must make some practical compromises—perhaps taking steps to see why self-scrutiny proves so threatening and what can be done to insure growth toward greater objectivity.

Superstitions, the outmoded folkways with which a changing society must always contend, and the propaganda and special pleading of individuals and groups with special interests constitute the chief external obstacles to reflective thinking. The science teacher can help students to discard superstitions and folkways that have lost their usefulness in part through guiding their study of particular ones. He may perhaps do better by helping them to develop ways of evaluating authorities and to understand both the fact of social change and its effects upon traditional or conventional ways of doing things. Methods of helping students become critical of propaganda and special pleading have been discussed in Chapters III, V, and VI.

Finding Opportunity for Students to Work Intensively on Their Problems

As suggested above, the Committee assumes that skill in reflective thinking and the disposition to use it depend upon wide successful experience in surmounting the problems which novel situations present and which students are interested in and recognize as having a bearing on their needs.

The following examples illustrate kinds of teaching in which teachers have attempted to work intensively with students on their problems. They are selected from many accounts of projects and problem methods now in use.

Case 1. In a tenth-grade biology course the class time, with the exception of one period a week, is given entirely to individual or small group projects. Students choose their own problems in consultation with the teacher, who spends most of the class period in conference at his desk in a corner of the laboratory. Students' problems range from genuine student research on bacteria in the air of the laboratory to the filling out of a workbook in botany. To pro-

vide for extensive acquaintance with the area of biology, one period a week is devoted to individual reports, and each student is expected to read approximately ten general books in the field of biology during the year.

CASE 2. In a twelfth-grade physics class there is a standing instruction that, at any time, a student may substitute an investigation of his own devising for the experiment suggested for the class as a whole. Two boys became interested in the problem of the part convection currents play in water heating, and they designed three types of apparatus in each of which they measured the efficiency of water heating. They wrote up their results and published them, with a foreword by the teacher.[2]

CASE 3. A college teacher of physics encourages his students to work on minor research problems of their own choice. One student attacked the problem of finding what foundation there is for the belief that unusually large numbers of watch springs break after thunderstorms. The story of his solution of this problem [3] indicates that a genuine experience in reflective thinking has values that an ordinary laboratory course does not touch.

CASE 4. In a discussion of the contribution of laboratory work to general education,[4] Professor Schlesinger of the University of Chicago describes the laboratory work in an elementary chemistry course which would help to train students in observation, in drawing valid conclusions, and in considered action. He suggests that the bulk of laboratory work should consist of assignments which demand laboratory experiment, as well as reference to textbooks and lecture notes. These assignments would moreover be aimed at solving problems which had grown out of class discussions and students' reading, and in which students were actively interested.

The following are examples of such assignments:

To identify a specimen as one of a limited group of metals

To find the relative "strengths" of various commercial washing powders

To test baking powders for carbon dioxide generated

[2] H. Emett Brown, Leon Rosen, and Gordon Wagner, "A Project in Physics," *Science Education,* Vol. 18, February, 1934, pp. 42–45.

[3] S. R. Williams, "The Collection and Creation of Knowledge," *Journal of Higher Education,* Vol. 2, November, 1931, pp. 415–419.

[4] H. I. Schlesinger, "The Contribution of Laboratory Work to General Education," *Journal of Chemical Education,* Vol. 12, November, 1935, pp. 524–528.

To decide whether a given substance undergoes chemical change when heated

To devise a simple method of preparing sulphur dioxide

To determine which of several molar solutions contains an unionized substance, and which a uni-univalent or other type of ionogen

It is clear that in such a course the number of assignments completed by a student would be far less than the number of "experiments" usually performed by following directions in an ordinary laboratory manual.

These examples may cause the reader to wonder how "the ground can be covered" if so much time is devoted to intensive problem-solving. It is true, of course, that a student cannot for himself discover more than a very minute fraction of what he has to know. Most of this he must learn from what he is told and from what he reads—supported to some extent by what he is shown in demonstrations of various kinds. The value of problem-solving through laboratory work in the school does not lie in the factual knowledge that may result from it but in the attitudes and habits of reflective thinking it encourages and in the understanding it gives of how the knowledge of science gained by the student from description was attained in the first place.

It is also true that in the course of solving problems that are important to him the student will acquire much information through reading, listening, and observation and thus will be "covering the ground" of factual information that is useful in general education. It should be clear that the kind of science teaching recommended in this report will result in the elimination of a great deal of the material usually taught in conventional science courses. If its point of view is accepted stress will be laid upon things that are important in meeting needs, at the expense of covering a wide area of factual information; there will be fewer experiments in the laboratory, but they will be more nearly genuine experiments. If the student develops sufficient adaptability, resourcefulness, and ability

in self-criticism, he may be expected to go on "covering the ground" all the rest of his life, as new problems arise for him.

Working on Problems Encountered in Meeting Needs

It is probably clear to the reader that the problems which the Committee believes the science teacher should help students to solve are those which they are likely to encounter in seeking to meet their needs. As stated earlier in this chapter, the Committee believes that students may acquire the disposition and ability to think reflectively about the problems of life, and may become adaptable, resourceful, and self-critical in meeting them, only through wide and varied experience in problem solving.

Problems for reflective thinking lie implicit in the four previous chapters on meeting needs in the basic aspects of living. No special or different problems need be devised to develop reflective thinking. In economic relationships, for example, the following are typical common problems in the solution of which scientific information is useful and upon which both young people and adults tend to focus their reflective thinking: "Can I depend upon Consumers' Research?" "What kind of sweater shall I buy?" "Should I support the T.V.A.?" "How is the number of unemployed estimated?" "Are there jobs for everybody if people look hard enough?"

Typical problems in social-civic relationships might be: "How can I help to make my home town a healthier place to live in?" "How can we make our school more comfortable in hot weather?" "What shall I do about buying silk stockings in view of the China-Japan situation?"

In immediate personal-social relationships the following problems are typical: "What am I to do now that my parents and I disagree about the way I should spend my evenings?" "Why are some fifteen-year-old girls so much further developed than others?" "Are boys whose voices do not change until they are seventeen likely to be less manly than others

when they grow up?" "Do boys who do not want to go out with girls have something wrong with them?"

And in the area of personal living typical problems are: "Do I eat too much starchy food in hot weather?" "Is Bonzo really good for a cold?" "What is the cheapest way to get all the vitamins I need?" "What doctor shall I go to?" "Why do some people seem to dislike me?" "What things in the Bible can I believe?"

"Is Bonzo really good for a cold?" Students will suggest several ways in which this question might be answered: asking a doctor, the school nurse, the druggist, friends who have used it, members of the class who have used it; writing to the American Medical Association; consulting the several non-profit-making consumer advisory organizations—Consumers' Research, Consumers Union, local organizations; writing to the Bonzo Company (Research Division), asking for evidence, testimonials, medical opinion, and other published material; collecting information on the growth of sales of Bonzo. In some schools it will be possible to verify the efficacy of the preparation experimentally.

The class can decide which of these approaches are feasible and which are likely to provide reliable information. Volunteer groups can collect the various kinds of data, evaluate their validity, compare them with other confirmatory and conflicting evidence, and draw valid conclusions. When actual experimental verification is possible, the criteria for a significant conclusion can be set up by the students themselves. How can the efficacy of Bonzo be measured if it is not an infallible cure? If it works better for some people than for others? If its efficacy depends partly on recommended concomitant treatment? The necessity of using a large test group, of avoiding selection in dividing the class into test group and control group, of determining the average duration as well as the average incidence of colds in each group, can be understood, and these procedures can be put into practice by students at the tenth-grade level.

In the solution of problems like this students will need to do extensive reading and to recall information gained in connection with the solution of previous problems. Much of their reading will be in material of a very different degree of objectivity from that in science books. They will have to evaluate advertisements and newspaper reports. They should be helped to recognize misrepresentation as one of the methods used to influence them, and to interpret data so as to secure a more objective basis for making judgments and arriving at decisions.

There are other kinds of problems that engage the interests of students as much as those in the foregoing list, although their connections with the basic aspects of living are not immediately apparent. For example:

How and why are lightning rods attached to buildings?
What evidence is there of soil erosion in neighboring fields?
What evidence is there in a quarry of prehistoric life?
What relations are there between animals' teeth and their diets?
What happens to a bulb if you plant it upside down?
What happens to caterpillars as they grow up?
What happens to various household substances when you heat them?
What changes do various metals undergo on exposure to air?

Questions like these might be classified in the area of personal living, for they represent the personal interests of the younger adolescent and his need for a world picture. Younger adolescents are intensely interested in practical activity—in working with their hands and in observation. Such activity helps to provide the sensual basis necessary for the understanding of what will later be learned from reading and from listening. Junior high-school students need a science workroom or laboratory as much as older students do, if not more. A variety of science books and magazines should be on hand, and the teacher should also plan visits to power stations, water-purification and sewage-disposal plants, dairies, hospitals, health laboratories, and farms.

From such very simple problems which demand little more than observation and manipulation the teacher can lead his students on to problems the solution of which depends to a greater extent on formulating hypotheses and submitting them to practical tests, as well as on measurement and simple calculation. For example:

How would you measure the thickness of a certain kind of writing paper if you had only a ruler to do it with?

How could you get an amount of sand of exactly the same weight as a piece of wood you were given, without a balance to help you?

Why do things look wobbly through some kinds of glass?

What happens when you lengthen the pendulum of a clock?

Why is it difficult to judge distances if you use only one eye?

Why does a cork loosely put in a bottle pop out when the bottle is warmed?

Why does a kerosene lamp burn so differently with the chimney on and off?

How could you make a water clock and upon what would its time-keeping qualities depend?

How much salt is there in sea water?

Why do bubbles form in tap water when you start heating it?

What effect have chemical manures on plants and what amounts give the maximum growth?

What happens if you put a layer of oil on the top of water in which mosquito larvae are living, and why is this?

What effect has boiling raw milk on the time it will keep sweet?

These problems give scope to thinking about the formulation of problems and of their solutions. The teacher should, for example, encourage his pupils to recognize that the problem, "How much salt is there in sea water?" must be restated before it can be investigated. They must recognize that this question must be a question of *proportion,* though it is not stated as one. They must recognize further that it is possible to interpret the question as referring to the weight of salt in a given weight or in a given volume of sea water. In raising such questions the science teacher can do a great deal to intro-

duce his students to a conscious recognition of the problem of giving precise formulation to scientific problems.

As students become older and their knowledge of science, their practical experience, and their skill increase, the teacher should lead them toward problems which become increasingly dependent for their solution upon reference to books and other sources of information. Every science laboratory should have a library in close connection with it. The teacher should also stimulate work on problems through which students will come to appreciate the value of the various methods of recording and tabulating data. They should also learn the value of arranging data in graphical forms through which the results of a large number of observations can be made to reveal significant trends or important deviations at a glance. The teacher should also give his older students every encouragement in formulating hypotheses and in drawing inferences from both tentative hypotheses and established generalizations. He may ask them to generalize on the basis of a number of facts which he describes to them, or to state what principles already known to them would help in the solution of a problem he propounds.

Helping Older Students to Become Aware of the Nature of Reflective Thinking

It has already been stated that the Committee assumes older adolescents may come to improve their ability in problem-solving if they are made more conscious of the nature of the process.

More mature students who have already had a good deal of experience in reflective thinking may be helped to become more conscious of it as a process through the occasional use of some such scheme as the following: [5]

Problem: State your own perplexity in the form of one or a few precise, simply worded *questions.*

[5] Adapted from a form devised by R. E. Horton of the Seward Park High School, New York City.

Hypotheses: Briefly state one or more possible answers that occur to you after thinking the question over. If you have more than one question in your analysis of the problem, give answers to each of them.

Experimentation: Devise an experiment or experiments by means of which you can test your hypotheses. List the steps in your method in the space below. In the laboratory perform the experiments you devised and record the observations you made, together with any measurements under the heading, *Observations.*

Method	*Observations*

Conclusions:

1. Decide by inspection of the facts whether any one of your hypotheses was correct.
2. If the evidence is against your hypotheses, state this as an answer to the question.
3. Next, if your hypotheses were unsatisfactory, look at the question and the facts and make another hypothesis. Try this on another work sheet and with other experiments if you need them.
4. Finally, make one or more statements of what use your conclusion is, or what other questions it suggests.

In adopting any such procedure as this the teacher must take the utmost care to prevent his students from getting the notion that problem-solving can proceed according to a formula. Its purpose is not to provide a scheme that is of direct applicability in the solution of problems, but to make students aware of what is involved in problem-solving, and of the values and pitfalls that lie in *stating* problems, *stating* the hypotheses that may be framed in connection with them, and *stating* the solution.

Encouraging Confidence in Scientific Methods

From the social point of view it is highly desirable that young people should acquire confidence in scientific methods and in their own ability to use them, since they will be called upon, as adults, to choose between different methods of attacking social and economic problems. Such confidence is mainly acquired through young people's own successes in solving actual problems. It may be increased by their being brought to understand how scientific approaches to problems have resulted in impressive achievements. The student's interest is likely to be usefully carried along by such dramatized accounts of discovery as are to be found in René Vallery-Radot's *Life of Pasteur,* Sidney Howard's *Yellow Jack,* Paul de Kruif's *Hunger Fighters* and *Microbe Hunters,* Sinclair Lewis' *Arrowsmith,* Cornelia Cannon's *Red Rust,* and J. G. Crowther's *Famous American Men of Science.*

Studies of actual researches of scientists may also help to encourage students, particularly rather older students, to have confidence in their own power of reflective thinking and in the results of scientific methods. Perhaps the most enlightening of all expressions of scientific thinking is to be found in Michael Faraday's diaries, whose educational values have been sadly overlooked. Bernoulli's account of his development of the kinetic-molecular theories of gases is also an excellent example of reflective thought. One of the best examples in the field of biology is Darwin's *Diary of the Voyage of H. M. S. Beagle.* Again the teacher might describe how scientists developed early dynamic theories, or theories of heat, adopting first one theory and then abandoning it for another that provided a more satisfactory explanation of known facts. He might also refer to original researches on spontaneous generation of life or those leading to the discovery of the planet Neptune.[6]

[6] A number of source books and reprints give the original account of important researches and are, therefore, useful in this connection. There are, for example:

LANGUAGE AND REFLECTIVE THINKING

The Rôle of Language in Reflective Thinking

In the preceding pages very little has been said about the part that words play in reflective thinking. There is no doubt that they play an important part in most reflective thinking, especially that which takes place over scientific questions. They play a more evident part in the statement of problems, of hypotheses, and of the solutions of problems. It would not be satisfactory to discuss the encouragement of reflective thinking without paying attention to the possibility of improvement of reflective thinking through improvement in the use and understanding of language.

Yet the process of reflective thinking is too complex for it to be possible to say definitely what part words play in it. The Committee believes, however, that it has the support of psychologists and others who have studied the relation of language to thought in assuming that reflective thinking is improved by increase in the ability to express oneself clearly in words and to recognize ambiguity and confusion in the discourse of others.

In view of this the Committee proposes not to proceed further with an attempt to examine the rôle of words in reflective thinking itself, but to devote the rest of this chapter to an examination of methods whereby teachers may help young people to order their thought with the help of words and to

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Henry Crew, *The Rise of Modern Physics,* 2nd ed. (Baltimore, The Williams and Wilkins Co., 1935).

Charles Darwin, *Diary of the Voyage of H. M. S. Beagle* (New York, The Macmillan Co., Barlow ed., 1933).

Michael Faraday, *Diary* (London, G. Bell and Sons, Ltd., Martin ed., 1932).

Bernard Jaffe, *Outposts of Science* (New York, Simon and Schuster, 1935).

William Francis Magie, *A Source Book in Physics* (New York, McGraw-Hill Book Co., 1935).

Harlow Shapley and Helen E. Howarth, *A Source Book in Astronomy* (New York, McGraw-Hill Book Co., 1929).

William Cecil Dampier Whetham and Margaret Dampier Whetham, eds., *Cambridge Readings in the Literature of Science* (New York, The Macmillan Co., 1924).

express themselves without ambiguity when that is their purpose.

Sources of Error in the Use of Words

The process through which young people learn to bring words into relation with experience is such a complicated one that the relation is not always adequately maintained. They may learn to use words in conventional patterns and to answer conventional questions by conventional answers without having learned to relate them to the experiences of things to which they properly refer (according to established usage). Thus they may learn to talk of the conservation of energy or of inferiority complexes without really understanding how these terms refer to experience. They may also fail to recognize what are the characteristics of the class of things which go by a particular name, and so may think of whales as having the characters of fishes or of bats having those of birds. Again, young people may fail to recognize the way in which the references of words are affected by their contexts (again according to usage.) The word *determine,* for example, has very different senses in the questions, "What *determines* the temperature of the liquid we are observing?" "How are we to *determine* the temperature of the liquid?" "Are we *determined* to continue with our observations?" In the first case the question is about the factors which control the temperature of the liquid (causally). In the second it is about the methods of measuring temperature. In the third it is about intentions. In such a question as "How is the temperature of this liquid *determined?*" the sense of the word is ambiguous.

All people are dependent upon others for their understanding and command of language. Young people are assisted in improving their effectiveness in thinking with the help of language when those with whom they are in contact, and especially their teachers, have a high standard of discipline in thought and communication. Lack of definiteness in a student's discourse or lack of recognition of indefiniteness in that

of others is a sign that his education is being mishandled in an important way. This will inevitably happen with teachers who lack discipline of statement (and with it of thought) and who would find themselves at a loss if they were asked to put what they have to say in terms that have a close reference to experience (as, for example, in Basic English).

Approaches to Language in Science Teaching

Workers in the physical and biological sciences have developed a precision of statement in these fields which reduces the degree of ambiguity and the likelihood of misunderstanding to a minimum. As a consequence, teachers of these sciences tend to concentrate on observation and classification, without giving any very deliberate attention to problems of language and communication. In other scientific inquiries, especially those concerned with men and society, precision in words is very much more difficult to attain, and workers in these fields still have far to go in perfecting their instruments of thought and communication. Their difficulty is increased by the fact that the phenomena they study are all described in terms of common speech—which is notably lacking in the precision necessary for a scientific study and prone to the pitfalls described above. Thus the attempt to approach social and human problems scientifically starts at a disadvantage.

Hence, conscious attention to problems of communication, though relatively unimportant as long as the teacher confines himself to physical and biological sciences, becomes very much more important if he seeks to encourage in his students a more scientific understanding and response to human and social situations. The Committee therefore believes that science teachers, in addition to encouraging their students' ability to observe and to recognize relationships revealed by observation, should encourage in them a greater and more consciously controlled discipline of statement. It is likely that they can contribute very much more than they do at present to young people's mastery of thought in all fields by giving

them greater mastery of language upon which thought so intimately depends. Through such a discipline students would not only avoid ambiguity in their own speaking and writing more consistently, but would also be more sensitive to ambiguity in what they hear and read. In addition they would perceive more quickly and clearly the issues involved in any practical problem and would be enabled to apply their experience more effectively to its solution.

For the science teacher to succeed in helping his students to use language more effectively, he must first help them to recognize that science has resulted in the course of a social process in which scientific discovery and the means of communicating the results of discovery have advanced hand in hand. He can do this by discussing with them the interactions of practice and theory in the historical development of science, or by discussing the process through which their own power of action and their theoretical knowledge have developed in relation to one another.

In the first approach he will be very much helped if the social-studies teacher has already brought his pupils to understand the part that language has played in the evolution of civilization. It should be the social-studies teacher's task to show how human coöperation is dependent upon communication, largely through language, and how the development of human culture depends upon the ability of human beings to learn from one another through communication by language as well as through direct imitation. It should be his task to show how the advance of civilization has depended upon the development of writing as a means of communication with persons distant in space or time, and as providing a means of making relatively permanent records of men's experience. He should also have shown the tremendously important part played in the making of modern civilization by the invention of paper and printing and the spread of literacy throughout the world.

Taking up this theme, the science teacher can bring his pupils to understand how the advance of science, like the advance of all other kinds of knowledge and action, is dependent upon communication and written records. He can also bring them to understand that the advance of science was a venture in which scientists of various kinds, technicians and technologists as well as others, coöperated, and that language played a vitally important part in this coöperation. He can show his students how much they themselves depend upon language both for their understanding of what they experience in the laboratory and for their knowledge of things they have not experienced directly. In relation to this he should also bring them to realize that they can find out for themselves only a very tiny fraction of what they need to know, either as potential scientists or as future citizens, and that their laboratory work is in part aimed at helping them to relate what they are and will be told as "theory," to what they experience in practice.

In the second approach the science teacher should, quite early, bring his students to understand that there is no very important distinction between their own everyday knowledge and scientific knowledge. The distinction lies chiefly in the fact that everyday knowledge arises in the course of attempts to achieve something practically useful, whereas most scientific knowledge results from the specific attempt to extend knowledge. Another distinction lies in the refinement, control, and accuracy of the methods used in arriving at scientific conclusions. Students' everyday knowledge as well as that which is usually called scientific comes through a process in which experience is amplified by verbal description and serves also to make the description intelligible.

Even the youngest children learn to recognize things as of kinds, to recognize distinctions, similarities, and other relations between things, and to express these relations in language. In doing this they have already started along a path

of which their scientific education is only a continuation. A child in learning to distinguish a dog from a cat and to name them properly is doing something of just the same kind he subsequently does in the laboratory when he learns that brass and gold are different substances, or that ice and water are the same substance.

Children learn to attach names, such as *dog* or *table* or *house,* to the objects of experience through hearing the names used in connection with them. They learn to "understand" abstract terms (such as *green* or *heavy* or *the weather*) and relations (such as *to the right of* or *afterwards* or *caused*) by a similar process. Experience in diverse situations enables them to grasp particular terms which refer to things, qualities, relationships, etc. They acquire excellent practical command of these terms without being aware of the process through which they acquire this command. They are likely to be quite at a loss if asked to explain exactly how these words apply to the particular situations in which they use them. This is rather like their ability to speak grammatically without being able to state the rules which they are observing in doing so.

But though most children's mastery of the words that refer to familiar things has become pretty complete by the time they reach adolescence, there usually remain a considerable number in the use of which they fail to recognize practical distinctions that are important for some purposes. For example, many people who have no training in science use the word *melt* in ways which show that they do not distinguish between melting and dissolving. Again, in using the word *hot,* many people do not distinguish between *feeling* hot and the weather *being* hot. In order to learn to use such words more precisely for scientific purposes, they must first recognize the distinctions between things or situations which make distinctions in statement necessary. When they have recognized this they can appreciate the distinction in statement that has been evolved to express the distinction in what is experienced.

Operational Definitions [7]

Of recent years a number of physicists, most notably P. W. Bridgman, have been stressing the fact that words can convey information about the world only in so far as they have specific reference to it. This has given rise to what is known as "operationalism." The operationalist when confronted with any statement asks what exactly it is that is being asserted, and by what specific operations it could be verified. For him, a statement can be accepted as scientific only when the assertion is definite in the sense that it admits of empirical verification. He points out, for example, that any one talking of a temperature of so many degrees can claim to know what he is talking about "in science" (and can understand similar expressions of others) only when he can describe the instrument upon which the measurement of temperature depends, the methods by which its scale has been calibrated, and how the instrument is used. This form of criticism was first suggested by a growing realization among physicists that many of the statements about space and time traditionally accepted as having reference to experience were, in fact, of a kind that did not admit of experimental verification.

A question which asks to what particular situation or operation a particular word or description refers can do a great deal to bring people to realize when they are using words without knowing how they relate to experience. Such questions, besides revealing weaknesses in particular individuals' command of particular terms also reveal that many terms which have been universally accepted from time immemorial have been used without any very definite relation to experience. The term *length,* for example, refers in the first place to extension of the kind directly perceived by sight, by touch, by bodily movement, or by all three together and which can be indi-

[7] The reader who is interested in these matters might well read Chapters II and III of *The Intelligent Individual and Society,* by P. W. Bridgman (New York, The Macmillan Co., 1938).

cated to others by gestures. It becomes possible to convey information about length quantitatively only when methods of measurement have been devised and are understood by those between whom communication takes place. Thus a statement that a given object has a length of so many units can convey precise information only when the methods whereby the statement was arrived at can also be stated. Most everyday measurements of the kind made by technicians refer to the familiar operations of measurement that are made with the help of commercially manufactured scales or rulers. These are accepted as "given," and in making a particular measurement and statement of length no reference need be made to the methods by which the conventional units were decided upon or to the methods by which the scale was made. In measurements of high precision such questions must, however, be asked.

The advance of science has been accompanied by progressive refinements in the technique of measuring the length of objects. Scales have been ruled with ever greater precision and for fine observations microscopes have been brought into use to read them. There is, however, a limit beyond which measurement is not possible. Even with present-day techniques it is not possible to measure the lengths of rigid objects to more than about five significant figures, though measurements of the wave-lengths of light can be made with considerably greater refinement than this. At every stage of the refinement of measurement the operationalist will point out that any statement about the length of an object has reference to the instruments and operations by means of which the measurement is made, and that the precision of statement is limited by the techniques of measurement employed. When the limit set by the techniques of measurement is reached, the operationalist's criticism becomes especially important. He then points out that no statement about the length of an object which goes beyond the possibilities of measurement can have any reference to experience. Thus the operationalist, if he

adopts a rigorous position, will object to people talking of the "real" length of an object and will point out that it makes nonsense to talk in this way, as there is a definite limit—set by possibilities of measurement—beyond which measurement is impossible.

The operationalist points out that the difficulties that arise over the measurement of the length of a body that is moving relatively to the observer introduce further difficulties about making a statement of its length. These difficulties, which were first recognized by Einstein, arise from the fact that measurements of space and of time cannot, under these conditions, be made independently of one another, which means that unqualified statements of length are impossible.

Attempts to give operational definitions to many terms of ordinary discourse show how very unspecific is the relation between these terms and the things or changes in things or states of affairs to which they are used to refer. This is most conspicuous in the use of sociological and economic terms, such as *democracy, the people,* or *money,* but it also holds true of many words like *melting* or *hot* or *temperature* that usually have very much closer reference to physical observations and operations.

Suggestions to the Teachers

What has been said about the ways in which science teachers may help their students to use language more effectively in ordering their thought and communicating it may be organized under three main headings. Teachers may help students to understand that:

1. For an answer to a question of fact to be unambiguously communicated it must be expressed in terms which (*a*) refer specifically to the operations through which the things about which the question was asked can be observed or measured, and (*b*) are so understood by the person to whom the answer is given.
2. For the unambiguous statement of answers to questions of

fact, new words may be invented or words may be taken over from everyday speech and given more specific technical sense.

3. The context in which such words are used serves to indicate that they are being used to convey this particular technical sense.

Because of the confusions in thinking that follow from lack of precision in communication, the remainder of this chapter is devoted to a discussion of examples taken from the various sciences which may prove suggestive to teachers in seeking to give their students a better understanding and mastery of language as an instrument of communication and thought.

Physics. Every teacher of physical science attempts to help his students learn what the terms *mass* and *weight* refer to, and what the distinction between them is. And every teacher has learned that verbal definitions and distinctions, made without reference to physical operations, nearly always fail. When a student who gives the common definition of mass as *quantity of matter* is questioned further, he usually either identifies quantity of matter with volume or becomes too confused to answer and makes only one thing clear—that the ability to give a verbal definition of a term is no guarantee that the term is understood.

A student is a master of such terms as *mass* and *weight* only when he has acquired the *power to say of what various things and under what various conditions* the term may be used according to established usage, and when he uses it in this way. The student learns what mass and weight "are" and what the distinction between them is by learning to carry out, in practice or in imagination, operations to which these terms refer and which make the difference between them clear. For example, he may learn about the variation of the "weight" of an object (measured with a spring scale) as it is carried from the equator to one of the poles. Or the teacher may set him the problem of describing what happens to the "weight" of a lead-filled football when it is taken into an elevator, is suspended from a spring scale, and the elevator is allowed to

fall freely. Then, to bring out the distinction between mass and weight, the teacher may ask what would happen if one kicked the football.

Such exploration could be carried further by examining the relation of quantitative statements to instruments and techniques of measurement. Physics teaching in the past has largely failed to bring young people to understand how expression of physical quantities has been simplified by the institution of the C.G.S. system of units. Even students who become proficient in using these units often fail to understand the ingenuity with which the foundations of the system were laid.

In developing a world picture young people should learn the practical referents of such words as *law* in its scientific sense. The student will not be helped much to understand what a law "is" by memorizing either a definition or a number of laws. The latter is likely only to increase his confusion about "law" in its scientific, statutory, and normative senses. He will understand the scientific sense of the word only when he has himself carried out work that brings him to understand how the recognition of relationship between a number of observations may serve as a basis for prediction, and when he is told that it is such a relationship that is referred to as *law*.

In connection with such work the teacher can show how the words *weight, mass, density, law,* and many others are taken over by science from common speech and given senses which are much more specific than and sometimes quite different from those which they have in common speech. Thus the various senses of the word *mass* as used in the phrases *mass warfare, a mass of rock, mass of public opinion,* and *the masses* can be usefully compared with the specific sense it is given in dynamics.

Again, after making clear the sense which the word *law* has in science, the teacher might well discuss with his students the various other senses the word *law* has in everyday speech, so as to help them use the word effectively in social-civic rela-

tionships. For example, during the latest presidential campaign, a well-known speaker told his radio audience that the Constitution of the United States was a "God-given law," just as was the law of gravitation. He implied that to change the one was as impossible as to change the other. This offered a splendid opportunity for a science teacher to point out the confusion that arises from a failure to recognize the various senses a word may have in common usage. To take another example, this time from economic life, the science teacher might well ask his students whether people always obey the law of supply and demand, and in what respects this law differs from a physical law.

Another indication of the usefulness of the operational mode of thought in the development of a world picture may be given by showing some samples of problems which have troubled physicists and philosophers for ages and which, according to operational criteria, have no solutions. It has often happened that the problems of one age have been meaningless or uninteresting to succeeding ages, but there are other problems which still look interesting. Take (from Bridgman [8]) the example of the problem of free will. Many people say that they are free to take the right or the left fork in the road. But after they have made one choice, what operations would show that they might have made the other? Since such operations cannot be described, the operationalist says that free will has no operational meaning; it may, of course, still relate to personal feelings while the choice is being made.

Many questions which appear to refer to the physical sciences have been answered—or rather abolished—by the operational technique. For example, what happened before the universe was created? Had time a beginning? Are there parts of nature forever beyond human detection? Why does nature obey laws? For each of these one need only consider what might be the form of observation or operation which would

[8] P. W. Bridgman, *The Logic of Modern Physics* (New York, The Macmillan Co., 1927).

suggest the answer to realize that no such operations are conceivable even in principle, and that therefore these questions are meaningless in the physical realm.

Chemistry. The student of chemistry usually begins with a study of the various chemical substances to be found in the laboratory. He is familiar with some of these through his everyday experience outside of school. As a result he fails to recognize that the materials with which he is concerned in his chemical studies are, in the forms in which he sees them, the outcome of the discoveries and achievements of chemists of the past. He accepts the word *pure* as applied to most of the materials he uses without realizing that the words *pure* and *impure* gradually gained their present chemical sense only through the gradual development of techniques of purification (distillation, etc.) and through the development of specific tests for purity. Thus he fails to recognize either how important such techniques were to the early founders of scientific chemistry or the relation of the present technical sense of the word *pure* to them. The science teacher could give his pupils a much clearer sense of all this if he started with the study of substances which were not already purified by artificial means, and then showed the processes by means of which the substances are purified and may subsequently be called pure. In this connection he might also point out that the "degree of purity" depends directly upon the refinement of purification techniques and upon tests of purity (for example, he might call attention to the distinction between chemically and spectroscopically pure).

Again the teacher might help his students to realize the crucial importance of the distinction between *mixtures* and *compounds* to the history of science. He should point out that this distinction could be made only in terms which had reference to practical means of making, analyzing, and identifying mixtures and compounds. The same is true of the distinction between *compounds* and *elements,* which refers directly to the operations by which they are prepared and identified.

It was not until operations had been discovered for electrolyzing caustic soda that caustic soda was recognized to be a compound. At a later stage it might be pointed out that the discovery of radioactive transformation and artificial transformation made changes necessary in the definition of the word *element.*

In traditional chemistry teaching, students were given a verbal distinction between compounds and mixtures which was then to some extent illustrated by examples that fell very definitely into one or other of the two categories. This had two very unfortunate results. It tended to prevent students from recognizing the operational basis of the distinction, and it prevented them from recognizing that the distinction does not apply at all to many fluids (for example, solutions) and to many familiar solids (crystals).

The chemistry teacher can also show students how words that are taken over into the technical vocabulary of science may retain more than one sense, though the context in which each of these words is used serves as a means of indicating which sense is intended on any particular occasion. The word *metal* in popular usage, for example, refers to substances which have a particular kind of bright appearance, which can be polished, and which are cold to the touch. The chemistry teacher substitutes for this identification (which depends upon direct perception) alternatives that may refer to chemical, to electrolytic, or to photo-electric experiments and operations. Some substances which are metals according to one operational definition are non-metals according to another. According to some operational definitions selenium is a metal; according to others it is not. Again, according to some definitions it behaves as a metal on some occasions while on others it does not. Discussion of such matters should lead the student to see the futility of asking whether selenium and bismuth and hydrogen are "really" metals or not, and to recognize that the word has a whole range of senses. What is most important for him to recognize is the sense in which the word

is being used by himself or by others on any particular occasion.

Biology. Biology also provides many topics the linguistic aspects of which have much to contribute to a fuller understanding of language in thought and communication. The objects of biology do not fall into such sharp categories as do those of chemistry or physics. The distinctions in experience which find expression in the words *herbivorous* and *carnivorous* or between the words *plant* and *animal* or in the words *heredity* and *environment* can be very usefully discussed in this connection. This should bring out the very important point that distinctions in language can retain a practical reference only as long as they do not go beyond the possibilities of making distinctions in perception or in action.

The same issue is very clearly brought out by the most important question, "What is life?" Here the teacher can bring his students to see that though living things are recognized by certain definite characteristics, there is a gradual transition through bacteria, viruses, and enzymes from what is definitely living to what is definitely not living. Where the line is drawn depends upon the particular operational definition adopted. Such illustration could then be correlated with illustrations from other subjects, such as the operational definitions of *compound* and *mixture* in chemistry and of *measurement* in physics.

The celebrated question, "Which is more important, heredity or environment?" is operationally meaningless in this form. Restated in the form, "Does heredity or environment play the larger part in producing an observed character?" it can be answered only when the conditions have been established for observing hereditary differences in standard environments, or observing environmental differences and their results in random groups or in individuals of the "same" heredity. It is such conditions that provide a basis for an operational definition of the terms *heredity* and *environment.*

This leads to the more realistic question, "Shall research into human heredity be intensified at the expense of research into the effects of the environment on human beings?" If the question is how to investigate human heredity, one of the ways in which to proceed is to subject a considerable group of human beings to a standard environment; since human beings behave differently in different environments, this uniform environment should be one of high viability. This is the conclusion arrived at by some geneticists (J. B. S. Haldane and Lancelot Hogben). If the question is how to investigate the effects of environment, then interest centers mainly in favorable environments, and such environments must be produced if their effects are to be investigated. Thus, for this statement of the problem, both alternatives lead to the same program, and the answer is phrased in terms of things to do.

If the science teacher attempts to help students answer their questions about their own growth and behavior he will have to bring into the discussion a whole range of words which generally lack precise definition. He will find himself talking of *instinct,* of *intelligence,* and of *"what is normal."* If his pupils have already acquired an understanding of how words that present less difficult problems acquire precision by being related to observations and operations, he can pass on to examine these words. He can make clear that questions of whether a person is normal or intelligent can be answered only when the meaning of the questions has been rendered more precise through defining the words *normal* and *intelligent* by specific reference to observations and operations. This can lead on to an examination of such questions as: "Is intelligence what intelligence tests measure?" "What makes up personality?"

The science teacher, by helping students appreciate the range of sense of certain words used in biology, can help them to avoid confusion over many questions that arise over these words in social-civic relationships. For example, in the question, "Are Nordics a superior race?" students can come to see

the importance of making operational definitions of the words *Nordics* and *superior.*

Conclusion. Discussion of problems and terms like those illustrated will do much to help students develop an understanding of language and of its rôle in reflective thinking. It should also provide a useful transition to a study of the more difficult problems of giving precision to the words used in discussion of social problems. Since experiments of the kind made in natural sciences are not possible in social studies, language in these fields cannot acquire greater precision through being used in the description of controlled experimental situations which result in the recognition of simple causal and other relationships. The language upon which social studies has to rely is the language that has been evolved by people during the conduct of their social affairs—people who had no knowledge of science and who had not yet recognized the conditions under which words and descriptions can acquire precision and so come to serve as a means of unambiguous thought and communication.

As things stand today, almost endless confusion arises in the popular discussion of sociological questions partly because the only terms available are sadly lacking in precision. Different people use and understand the same terms in very different senses. The Liberty League, for example, uses the word *liberty* in a different sense from that in which the Civil Liberties Union uses it. Confusion arises to an even greater degree because people overlook the complexity of the things they are talking about in contexts where this complexity is important (for example, "America wants this or that") or because they introduce words that contain an expression of personal feeling or intent in disguise (as, for example, when people talk of something being *necessary*—implicitly claiming that the end for which it is necessary *ought* to be desired by others, even though it may imply a personal belief or interest of their own).

When one is told that a *nation* wants peace or colonies, he is entitled to ask the meaning of the words *nation* and *wants* in

this context. How was it determined that the nation wanted this or that? Is the nation all its members, or a majority, or a group in power, or an economic class, or a fiction used by a dictator to give weight to his own wishes, or what? Until such questions have been answered, no precise meaning can be given to the statement.

It is not possible to give terms precision through statute (except in a few special cases, like the statutory definition of metric units). Even in the natural sciences most terms come to be generally accepted in a definite sense only through the gradual development of a consensus of agreement. The teacher must not try to assign precise meaning to words that lack it. He can, however, help forward the social process through which words acquire greater precision by making his students aware of the variety and range of senses in which words are used; of the misunderstanding and confusion to which lack of precision in their use gives rise; of the serious consequences which often follow from this misunderstanding and confusion; and of the actual process through which words may acquire greater precision. In all of this he will also be helping to promote a greater common understanding among people—a common understanding of their differences as well as of their agreements—and so he will be contributing to the smoother and more effective working of democratic institutions.

Part III

UNDERSTANDING THE STUDENT AND EVALUATING HIS GROWTH

VIII

UNDERSTANDING THE STUDENT

INTRODUCTION

The Relation of This Chapter to the Report in General

This report stresses the continuous interaction between the individual and society, between personality and culture. An early section sets forth certain personal characteristics conceived to be of importance for the achievement of major social ideals: it says, in effect, that the classroom situation must be devised to foster characteristics conducive to the optimum development of personality, reciprocal individual and group responsibility for promoting common concerns, and the free play of the intelligence as a means of continuous reconstruction of individual and group experience. These characteristics must be nurtured in individuals both for the sake of the individual himself and for the sake of his greatest social effectiveness.

In taking this position, the Committee conceives of experience as an interaction between the individual and his environment, an interaction which changes not only the situation but the person as well. The characteristics of the person at the time he is confronted with a situation affect both the nature of the experience and the changes which occur in him as a result. To a child, for example, thunder is a loud and frightening sound; to a savage it is the anger of the gods; to the civilized adult it is a natural phenomenon. The same situation constitutes a different experience for each; it affects each differently in accordance with his previous experience. Hence the classroom situation must be contrived in terms of the student's present characteristics if growth in desirable directions is to

take place, and present characteristics can be understood only in the light of their origins in past experience.

This chapter treats of the nature and development of the adolescent's present characteristics; it is based on the fundamental conviction that knowledge of that development will assist the teacher to provide experiences through which the adolescent may grow to higher levels of socially desirable characteristics.

Further, the chapter is intended to sensitize the teacher toward problems of adolescents in general, and to serve as a background for distinguishing the area in which he himself is capable of helping the student to make a desirable adjustment from that in which it is advisable for him to ask advice from some expert source. The potentialities of personal contacts are emphasized, as well as the basic understanding of adolescent development, in order to provide the teacher with some reliable background for establishing a positive relationship with his students—as indispensable in dealing with everyday situations as in guiding students who exhibit more serious problems.

UNDERSTANDING THE ADOLESCENT

The Adolescent as the Teacher Observes Him

Before discussing the development of the adolescent, it may be helpful to describe the adolescent as he appears when casually observed. A description of his behavior from this empirical standpoint makes it possible to single out those attitudes and traits which set off adolescence from childhood on the one hand and maturity on the other. The necessarily incomplete picture thus arrived at is familiar to every teacher, who will be able to make his own additions in accordance with his personal experiences and recollections.

Children leaving the elementary school, with its maternal home-room situation, very soon show characteristic changes in behavior in their new high-school environment. They seem to

acquire entirely new patterns of personality in all their essential relationships, patterns that are often discouraging and discomforting to adults. Certain firmly established ways of behaving seem suddenly to have disintegrated. The child who was formerly more or less quiet, gentle, and affectionate suddenly exhibits varying degrees of uncouthness and lack of consideration for other people—especially for those (like his mother, father, brothers, and sisters) who were previously very close to him—and an increasing emotional instability and physical restlessness.

The younger adolescent's types of interest are also significant. During the early teen years, his interest in science is limited to great absorption in manipulation, construction, experimentation, as values in themselves. Shifts of interest are frequent, and the span of attention seems shorter than it used to be. Difficulties in concentration and learning come more often to the teacher's attention. Creative abilities in the different arts tend to diminish and are more or less replaced by a tendency to produce realistic and unimaginative configurations.

The younger adolescent fluctuates easily from fighting and rough-housing to withdrawing and day-dreaming. His books are not kept as neat as they used to be. His sense of punctuality and order deteriorates markedly. His everyday language undergoes a change, and a great number of slang expressions and "dirty words" are incorporated into it. A good deal of secretiveness manifests itself in relation to age mates or adults, and greediness for sweets is often very pronounced. Finger-nail biting is observed to be more frequent than it was before. Personal appearance is neglected (this is particularly true of boys); unless pressure is brought to bear, shoes are not laced, shirts are not buttoned, hands are not washed, finger nails are not cleaned, hair is not brushed, and so on.

At this time also, group formation undergoes a decided change. Whereas in the elementary-school groups formed spontaneously in the classroom normally included boys and

girls, there now appears a noticeable tendency for boys and girls respectively to form their own exclusive groups. Contacts between boys and girls are not only not sought; they are intentionally avoided. On the basis of this one characteristic, the time of early adolescence is often referred to as the "gang age."

This type of behavior endures, with individual deviations, for only a few years. Gradually, with increasing maturation, another change takes place. In middle and later adolescence more mature interests develop; intellectual activities are often pursued with enthusiastic devotion; the creative spirit is reawakened and seeks expression in the media of the different arts. A few more mature adolescents are capable of outstanding achievements in intellectual work as well as in imaginative creativity. Teachers sometimes credit such young persons with genius-like abilities and are disappointed when they find that the promise of genius is not fulfilled as the student grows into adulthood. The interests of later adolescents widen to include social and cultural relationships; they tend to identify themselves easily with social groups (most often with the underprivileged) and with outstanding personalities in different fields of human endeavor. Personal appearance now becomes a very important concern. Neglect is unusual, for the young person is developing an increasing interest in the opposite sex, a need for contacts with age mates and adults outside the family, and a great desire for popularity and for experimenting with new situations. Emotional instability still dominates the picture. But the adolescent of this age is deeply concerned about his future and his social adjustment, with adulthood as his general goal.

It must be remembered that each individual develops his own outstanding characteristics at a different rate and at a different age; but for descriptive purposes those most frequently observed have been summed up in this discussion to illustrate the bewildering variety of personality traits with which the different developmental levels confront the teacher. Only through understanding these traits in terms of a con-

tinuous development of personality can their enumeration be stripped of its puzzling incoherence, and a consistent and comprehensible pattern be discerned.

The Reasons for a Developmental Approach

The psychologist phrases characteristic traits of personality in terms of growth from previous stages of development and calls attention to the fact that the current characteristics of the individual—his present stage of development in relation to social participation, intellectual interests, or whatever—originate in and incorporate the outcomes of his previous personal experiences dating from infancy. Hence the necessity for understanding the development of these characteristics from infancy onward.

This necessity would hold true of the attempt to understand the human personality at any time of life, because past experience makes the person what he is. It has long been recognized by layman, psychologist, and poet alike that the child is father to the man. Comparatively recent clinical research has lent special emphasis to the prepotency of the early years in establishing the patterns with which the developing person meets new situations throughout life.

But there are special reasons for an examination into the personality patterning and reactions of early childhood when attempting to gain an understanding of adolescents, for adolescents tend to fluctuate between infantile and adult behavior. Further, adolescence, like early infancy, is a period during which rapid changes in body structures have marked bearing on the emotions and the intelligence, and new relationships are being established within the organism and between it and its social medium. The general condition of growth and reorganization during these two periods offers similar opportunities for stimulating growth in desirable directions and for avoiding the obviously far more difficult and painful remedial measures required after warpings and distortions have been incurred.

The interpretation of developmental factors basic to this chapter is derived from mental hygiene [1]—the study of [2] "human relationships, of personality, of character, the intricate play of physical, intellectual, and emotional forces within the individual and the reaction and counter-reaction between this total play and similarly intricate factors without the individual."

The mental hygienist believes that behavior is learned. There is nothing startlingly new in that belief. Parents and teachers have always subscribed to it and for that reason have attempted to "train" the child. The newness lies in conceiving of behavior as the methods whereby the individual uses his physical, intellectual, and emotional capacities to get what he wants from the environment. When behavior is viewed in this light, it becomes necessary to know what a person wants in order to be able to help him achieve it in ways which are so-

[1] "Mental hygiene, like medicine, is an art—not a science. Medicine draws its material from certain fundamental sciences. The practice of medicine is the art of applying the knowledge gained from these sciences to the curing of illness, or, in a broader sense, to the prevention of illness and the maintaining of physical health at the level of the individual's physical potential.

"It is not enough to be a master of the basic sciences alone. One may be filled with this knowledge and yet be a poor physician. The art itself has developed its own body of knowledge from the experience of the practitioners of the art and its own special technique. A knowledge of this special body of fact and of this special technique is necessary before one can hope to become a fully competent physician.

"The same fundamental scientific principles obtain in the practice of the art as in the basic sciences themselves. Medicine can, therefore, be said to be scientific, although not a science.

"Mental hygiene likewise is an art rather than a science. It is the application of knowledge gained from certain basic sciences to the problem of mental health, broadly interpreted. The basic sciences are the same as in medicine, but with special dependence upon those sciences concerned with the nervous and psychic system, such as neuroanatomy, neurophysiology, neuropathology, psychopathology (not psychiatry, which is a branch of the practice or art of medicine), and psychology. Its technique is derived from the techniques of medicine, psychiatry, psychology (as an art), education, and social-case work. The same scientific principles obtain in the field of mental hygiene as in the basic sciences themselves, and again, as in the case of medicine, mental hygiene can be said to be scientific, although not itself a science." [Frankwood E. Williams, *Adolescence: Studies in Mental Hygiene* (New York, Farrar and Rinehart, 1930), pp. 194, 195.]

[2] *Ibid.*, p. 197.

cially effective and personally satisfying. Only then will he be freed to grow to higher levels of wants, and better and better ways of achieving them.

For example, if his behavior is "show-off," it may be changed without insight by punishment at each manifestation, but the individual will still want attention and still be at a loss as to how to get it in socially valuable ways which do not antagonize. He will be thwarted in the next stages of his growth. Only when his parents and teachers have insight into what he wants can more acceptable behavior be learned in ways which will free him to get better and better kinds of attention through better and better kinds of contributions to the situations in which he finds himself.

The "show-off" is not ready to accept the fact that he is looking for attention. He is ready to learn new ways of achieving it on more mature levels and will find these satisfying once he is helped over his sense of privation. But in order to guide the learning, it is necessary first to see showing-off as the drive for attention. Dealing with the show-off manifestation merely will discourage it without providing more acceptable means for attention-getting. In other words, the whole person, with the whole of his thwartings and persistent unsatisfied desires, must be taken into account when deciding what he is now ready for, what will in fact prove satisfying to him as a whole and evolving personality.

The conclusions arrived at through the technique of mental hygiene may not be correct in the absolute sense, but experience has shown that they are more effective in understanding and changing behavior than any available in the past; hence their use is justified.

The Adolescent as the Teacher Understands Him

Reliable psychological evidence has shown that the individual's experiences during infancy and childhood to a very high degree determine his behavior and development in adolescence and adult life. This evidence has been borne out by the

findings of the Study of Adolescents. Therefore, any attempt to understand adolescence must necessarily take certain phases of childhood development into account.

In the very beginning, the infant is entirely self-centered and is wholly absorbed in bodily gratifications which are expressions of the self-preservative functions, like ingestion and egestion. But very soon it establishes a relationship with the person who has charge of it, the person on whose presence and willingness it must depend in order to survive. This relationship naturally assumes an affectionate character. It is very important that this be so, because it helps the infant and child to endure necessary restrictions of their primitive gratifications; their outgoing interest in other people and their positive attitude toward them predispose them to bear unavoidable frustrations and make them willing to abandon their infantile ways in favor of those approved by adult standards.

Gratifications which psychologists call *infantile* or *primitive* are those forms of activities or psychic processes which gratify needs directly, without consideration of any socially or culturally conditioned standards. Primitive needs become socially desirable characteristics only as the person goes through a process of education: the child must have experiences appropriate to his age, through which he may reliably achieve desirable growth. Seeing that the child does have these experiences constitutes one main function of education.

The most highly valued cultural activities grow from roots in primitive drives. For example, the tendency to destroy things, to find out what is inside them, is a normal activity for a three-year-old child, and it expresses a primitive need. Raised to a higher level through education, this need may later manifest itself as intellectual curiosity about objects or ideas, a characteristic of great cultural value. It is obvious that distortions on the early formative level are likely to have an adverse effect on the child's attitudes at the age when high-school teachers first come into contact with him.

Interest is averted from primitive goals during the preschool

years. This process is facilitated by the child's complete dependency. The danger of losing love produces anxiety in the child; to avoid this unpleasant consequence, he prefers, if proper opportunity is given him, to accept and incorporate the requirements of his environment. It is thus possible for the home to establish certain standards of conduct. The elementary-school years provide opportunities to achieve self-reliance and social adjustment through the child's increasing identification with the adult world.

At about the age of ten to twelve, when the child comes to the lower levels of the secondary school, definite signs of physical maturation appear, paralleled by an increased urge to activity, which in the beginning is without definite aim. This urge, which is felt by the young adolescent himself as a mere bewildering unrest, gives rise to insecurity and anxiety. The child entering adolescence finds himself unprepared for this sudden invasion of instinctive drives, does not know how to respond or how to dispose of them in order to reëstablish the equilibrium he enjoyed during the years preceding. He has no adequate motor or emotional outlet for these urges, but the increasing tension requires some kind of release as a protective measure.

Quite desperate and unable to cope with the situation on a mature level, the adolescent of this age "rediscovers" his infantile habits of bodily gratification and takes refuge in them as a kind of emergency relief. Even well-established values and standards break down suddenly under the new strains of early adolescence.

This tendency to revive infantile behavior patterns throws some light on the picture of young adolescents as it was sketched above. Disregard for personal appearance, for clothes, and for cleanliness; untidiness and lack of orderliness in caring for personal belongings; finger-nail biting, speech habits, cruelty, greediness, and the like, can now be understood as a recrudescence of behavior which originally characterized an earlier level of development. Even in his turning away from

the opposite sex the young adolescent is merely avoiding the issue of his age and the significance of his maturation. The shift of emphasis in his areas of interest has a similar background. His pronounced interest in concreteness, in manipulation and experimentation; the decrease in his creative and imaginative powers; and his clinging to realistic configurations serve as a preventive measure to avoid the open display of emotional material.

The step from early adolescence to middle and later adolescence is characterized by the introduction of a new mode of relationship into the young person's life—the heterosexual adjustment. This is necessarily accomplished by an emancipation from the home, a process which often gives rise to violent clashes with parents. Progress toward both heterosexual adjustment and emancipation from the home proceeds at different rates and with frequent relapses into previous levels of adjustment. Children who are unduly attached to their mothers or to their homes ordinarily have a much more severe struggle in attaining normal relationships with age mates and adults outside the family. Fluctuating feelings toward the members of the family are often carried over into the school and are reflected in relationships with teachers and other persons in authority.

The age at which the adolescent attempts to solve his personality problems on a mature (not infantile) level sees a shift in his interests as well as a change in his behavior. This again is a manifestation of the general attempt to break through the family boundaries in order to widen the scope of his identifications. Every teacher is familiar with the older adolescent's increasing interest in problems of greater social concern and more universal scope, with his outgoing search for values and for information in wide areas of human endeavor.

It is to be carefully noted that the two stages of adolescence overlap, and that there is no sharp line of demarcation between them. Both early and later adolescence are characterized by unusual behavior, feelings, conceptions, and exaggerated

reactions. Knowledge of the fact that normal adolescents try at first to solve the emotional problem of maturation on an infantile level, which is in itself disturbing to adults, explains certain familiar educational difficulties. These difficulties sometimes assume such proportions that the teacher's judgment is subjected to serious strains. In such cases especially, it should be borne in mind that unless all the manifestations accompanying the return to infantile patterns are regarded as merely temporary, they may be forced into stubborn perseverance. When infantile and mature tendencies alternate and blend during middle and later adolescence, the young person's behavior and state of mind might be considered neurotic or even psychotic were they exhibited by an adult. Teachers must neither worry about these types of behavior nor seek ways to avoid them; they must instead accept them as legitimate and focus every effort on providing opportunities and experiences of reliable significance in helping the adolescent in his attempts to reach emotional maturity.

Wherever retardation or distortions in the emotional development occur, it has been shown that they manifest themselves most clearly along the lines of social adjustment. Whenever this area of relationship is disturbed, it is the duty of the teacher to investigate the causes. If necessary, expert advice should be sought, and special help offered to the student.

SOME DEVELOPMENTAL FACTORS RELATED TO DESIRABLE CHARACTERISTICS OF PERSONALITY

The Identity of Desirable Personality Characteristics and "Emotional Maturity"

It is to be noted that the desirable characteristics to be fostered by the teaching of science as outlined by the report correspond to the qualities which the psychologist refers to in terms of "maturity." These characteristics are inherent in the behavior of the individual throughout life—rudimentary in infancy and ever more highly developed and socialized in

childhood, adolescence, and adulthood. The attempt to increase social sensitivity, for example, as indicated in the second chapter of the report, involves helping the adolescent to enter always more appreciatively and sympathetically into the lives of others. The psychologist recognizes, in parallel fashion, that the adjustment of the adolescent in terms of group life is intermediary between his highly personal childhood relationships to the members of his immediate family and the adult ability to work objectively with wider and wider groups. The same is true of the other characteristics of personality outlined in the report. Each of them either develops *pari passu* with increasing maturity or is identical with it. Thus, self-direction and independence of thought are concomitants of psychological emancipation from the control of parents and their surrogates. Reflective thinking improves in quality as an individual develops the ability to consider the data of his experience without distortion by childish wishes and cravings. And so on throughout the list.

What, then, are the developmental factors related to some of the characteristics of personality which are conducive to the preservation and enhancement of democratic ideals?

Reciprocal Individual and Group Responsibility for Promoting Common Concerns

Ultimately, effective social participation in a democracy is dependent upon mutually satisfactory patterns of relationships between persons. How does the individual progress from the complete self-centeredness of infancy to the genuine give and take of the mature adult?

The new-born very soon begins to establish relationships with persons. Since parents, brothers, and sisters are the first persons with whom the infant comes into contact, the very earliest relationships are established with family members, and fundamental patterns are laid in terms of interaction between infant and mother, infant and father, infant and siblings.

For the first weeks of life, the infant is unable to discrim-

inate between self and not-self. As he is unable to distinguish between the parts of his own body, so he cannot differentiate objects and people from himself. If he is hungry, he cries and is fed. He expresses a wish and it is gratified. He makes his demands upon parent or nurse without awareness that they exist as separate persons, and hence without any regard to their convenience. He knows nothing of "other," of "person," of "convenience." He has an "illusion" of supreme omnipotence.

Experience early modifies the illusion. There are occasions when he cries, but is not picked up; he wails and is not fed; he sleeps and is waked. A vague awareness of self as distinguished from the parent emerges—a recognition that there is a separation, a cleavage of some kind, between the individual who satisfies his wants and his own person. He still tends for a while to look upon his parent as a functioning member of himself over which he has complete control. But the member is at times recalcitrant, at times compliant.

He still acts on the principle, "I want what I want when I want it." Whoever gratifies his wishes wins his love; whoever thwarts him incurs his anger and dislike. His instinctive reactions must be modified and redirected. It is inevitable that some of them should be frustrated if he is to learn to live happily with others, and when he meets frustration, he reacts with anger. Hence his parents must become the first objects of both his love and his dislike.

Wise parents keep anger at a minimum by thwarting the child's wishes infrequently, and only when they are really detrimental to his growth, and at a later age by helping the child as far as possible to understand the validity of the reasons for adopting a given mode of conduct. By testing out his parents' demands, the growing child soon learns whether or not they are valid in terms of his welfare. If the outcome of his course of action consistently bears out his parents' predictions, he follows their suggestions, and his resentment is minimal on those occasions when they are compelled to thwart him. He comes to be sure that he can trust and rely on his parents, that they will

not mislead him, that they love him. He becomes so sure of their love that he knows he will not lose it even if he does something of which they do not approve. This gives him freedom to accept or reject the word of parents, adults, and authority in general on the basis of his own experience, at the same time that he maintains a warm and outgoing relationship.

Unfortunately, most parents stimulate much unnecessary anger by thwarting the child with undue frequency because his behavior runs counter to their own comfort, convenience, or prejudice. They thwart him in terms of their own annoyance rather than in terms of his growth. They say, "You stop that, this very minute," or "John doesn't want to worry Mother, does he?" or "You know, dear, I'm doing this for your own good." Their predictions about the outcomes of a course of action are frequently disproved by the child's experience, and as a consequence he becomes unsure as to the probable results of his own conduct. When frustrated often and without cause apparent to himself, he rebels; he finds it especially difficult to cope with thwarting which cloaks itself as kindliness or consideration, because he cannot feel justified in expressing his anger. He regards continued thwarting of his wishes and activities as lack of understanding, and therefore lack of affection. He cannot rely upon his parents' love, for the reasons they give him are no sure guide. Without security of their affection and without confidence in what they tell him he is afraid to proceed on his own. He is therefore compelled to fall back upon their untrustworthy authority. He does not feel sure of people and tends to approach them with distrust.

Some children, feeling themselves unloved by their parents, handle the situation by rejecting the parents in turn. The antagonism which they feel so keenly is in direct conflict with their genuine love; the internal warfare prevents self-integration as well as happy relations with the outside world. They are swayed now by one emotion, now by the other, and their relations with people waver.

Other children react with submissive compliance to all the

demands which adults make upon them. They attempt to deny their own contrary desires, even to themselves. Along with their wishes, they hide the antagonism they feel. Their greatest fear is that they may in some way or other displease some one. For that reason, they dare show no initiative. Their duty is to conform. They accept the bonds imposed upon them, become very compliant, and rely upon direction from others. In relationships with other people, they are insecure, afraid of losing standing. But underneath their surface submission lies a seething hostility. Much of their energy must go into concealing this from themselves and others, into avoiding situations and personalities that are likely to reveal it. Watchfulness becomes their chief concern, at the cost of spontaneity of expression and deep feeling. And just as they continue to act like good little girls and boys, so they expect others with whom they come into contact to be good fathers and mothers, good older brothers and sisters to them.

It may be said, then, that parents' behavior largely conditions the child's reactions to other people. It also conditions his feelings of personal adequacy. As the child becomes increasingly aware of the difference between himself and parent, he relinquishes the illusion of his own omnipotence and develops a belief in the omnipotence of the parent who gratifies his wishes. Then he discovers that he cannot continue to expect complete gratification from his parents. They expect him to begin to gratify his own wishes, to rely more and more on his own developing abilities, and to substitute ever greater independence for complete dependence upon them. Disillusionment about his parents' omnipotence and withdrawal of complete protection cause the child to feel defenseless and frightened.

He needs to overcome this feeling and does so in a number of ways, with the help of his parents and parent surrogates. Absolute confidence in his parents' integrity and love is essential. He tends to take as his own their wishes and standards and thus becomes more sure about his behavior even when

they are not actually present to guide him. On the other hand, as indicated before, he relies upon their love enough to go counter to these standards when occasion seems to warrant. His success in progressive achievement dispels his sense of being defenseless and leads to further achievement and independence; occasional failures do not discourage further attempts. Growing physical strength and increased competence to manipulate the environment contribute their share to the development of self-assurance.

The child who feels secure with his parents and with himself will not be unduly disturbed by the arrival of a new brother or sister, especially if he has been prepared for the child's coming. But if he is not sure of their love, he is afraid that the new child will take away the little love which he has. Differences between the ways in which his parents treat him and the ways they treat the new baby are quickly noted; he interprets them as preferences and develops strong feelings of antagonism and jealousy. If the baby is of different sex, the child may believe that differences in treatment are to be accounted for on that basis and that one sex is favored above the other. Again the parents can overcome his feeling of defenselessness by tacit assurance of their love and by increasing his confidence in his own ability. In this new relationship, the child has opportunity to learn either intense jealousy of others or coöperation, consideration, and tenderness. He will tend to transfer the feelings which he develops in this situation to playmates and other sibling substitutes.

The child whose training has been fortunate learns, then, at a very early age, to establish satisfactory relationships with adults of both sexes, with himself, and with brothers and sisters. As he grows older, secure in the love which others feel for him and which he feels for them, free to express his abilities in achievement, and able to maintain himself in competition with others, he develops a technique for getting along with people which brings mutual satisfactions. The behavior of the child whose background has not been so fortunate—and

this is the rule rather than the exception—will give evidence of the ways in which his social development has been thwarted and of the places at which he needs help.

As outlined before, both most and least favored adolescents normally exhibit throw-backs to earlier stages of development. When floundering for ways to meet a new situation, they frequently fall back upon patterns that proved satisfactory in their very early experience. It is obvious that when the school situation first replaces the home situation, students have few patterns with which to react toward teachers and classmates except those which they have developed toward parents and siblings, and every teacher has observed childlike patterns in student behavior: unawareness of the existence of others, for example, or hostility to every suggestion, or a fear of proceeding without suggestion.

The Free Play of Intelligence

Attention has been called to the way in which the child's attitudes toward his parents condition his freedom to accept or reject authority—to go independently where the evidence of his own experience points. It may be noted that the relationship to brothers or sisters often is a determining factor of adequacy just as important as the relationship to parents. Early relationships bear likewise upon such aspects of the free and effective play of intelligence as willingness to learn and the unhampered functioning of curiosity.

Willingness to learn, like social participation, originates in a relationship with parents and siblings. For example, the child hears an adult use a long word and repeats it. His mother is surprised and delighted. He learns that by being bright, he wins attention and approval. His wish to learn is increased by the satisfaction which such praise and attention give, and learning becomes associated with a pleasant feeling state. This pleasant feeling state induces a relaxation and freedom from tension which leave the child free to turn his energies to persons and things about him and to learn from them; his energies

are not diverted to concern with unpleasant feelings occasioned by disappointment and frustration.

On the other hand, the child who feels that his mother does not love him for himself, that she loves him for his learning ability alone, may refuse to learn in order to hurt and punish her. He frequently wants to get some reaction from her, even preferring an undesirable response like a scolding to complete indifference. "She likes me only when I am bright. She likes my brightness rather than me. I am angry with her. I will not love her if she does not love me. I will not give her the satisfaction of being bright. I will do poorly in school. She will be sorry." The child may be thoroughly conscious of such purpose; he may be dimly conscious of it; or he may be totally unconscious of it. Whatever the state of his awareness, the end result will be the same. Resentment and unwillingness to learn will manifest themselves, for the time being at least, as inability to learn. As a result of such temporary disability, the child often loses ground, is discouraged by all that he has failed to grasp, and comes to dislike learning.

When a child goes to school, he tends to transfer previous responses to the new learning situation. To him, the teacher is another mother; the members of the class are brothers and sisters vying for attention. He expects the teacher to be as delighted with his learning as was his mother and will be as eager to learn in order to please. If the teacher meets this expectation, he will be stimulated to further intellectual activity. He will furthermore like school as a situation which affords him opportunity for pleasurable experience.

If the teacher does not respond favorably to him, he will react as if his mother were turning him aside, and will respond with anger. He will reject whatever the teacher says; he will refuse to take in what the teacher tries to teach him, just as he will push aside a disliked adult who tries to embrace him. His resentment will frequently express itself as inability to understand or failure to hear what has been said. It will result in dis-

tortion of what the teacher has actually said to make it conform to the lines of the rôle which the child has assigned to him.

If the child feels worried and guilty about his spiteful feelings toward the teacher, he may turn the spite against himself. Instead of punishing the teacher, he may punish himself. Instead of refusing to listen to what the teacher says, he may listen only to what can cause him pain; if the teacher says nothing which is itself painful, he may construe remarks in such a way that they will cause him pain. The child is frequently unaware of such wishes and the distortions of content which arise from them. That they have an effect upon clear understanding and impartial observation seems obvious.

The development of an active curiosity is influenced by similar factors. The small child is very naturally curious about himself and the world in which he lives. While still lying in the crib, he investigates everything in reach. At a very early age he begins to ask questions about himself, about other people, about the objects around him: "Why does the bird fly?" "What makes the airplane stay up?" "Who made me?" "Where do babies come from?" If his questions are answered freely, honestly, and in such manner as to give him a sense that the adult approves of his questions and of him for having thought about and asked them, he continues to wonder and inquire at will.

But many of his questions are concerned with sex, since the human body is a source of major interest to every growing child. He will ask questions about the differences which he observes and about sex in general. Unfortunately, few parents are able to answer questions in this area without embarrassment or evasion; they frequently distort the facts: "How do people get babies?" "By eating a lot and growing big."

The child tends to interpret embarrassment, evasion, and postponement in response to his questions as a negative reaction to himself. To him it means that he is being turned aside, rejected; that he does not count as a human being; or that he is a source of displeasure and annoyance, is not loved.

He reacts with anger. At first he does not cease to wonder, but his curiosity has associated with it feelings of resentment which interfere with learning. If he is rebuffed often enough, he may give up asking. If his questions have met severe punishment, he may try to avoid even wondering, having come to feel that it is "bad."

Further, the child is confused by the fact that he is permitted to ask about what makes the automobile go and to take apart an old clock to see what is inside but he is not permitted to ask about where babies come from or to examine the bodies of other people. There are some areas about which it is "wrong" and "bad" to wonder—there may be others; he does not know. In finding out he runs the risk of punishment. This fear restricts his active exploration into and inquiry about his world and may continue to limit the active functioning of his curiosity even in adolescence and adulthood.

Some children do not react in this way. They do not swallow their anger at being rebuffed, at having their questions ignored, frowned upon, or untruthfully answered; neither do they give up their quest for information. They say, in effect, "All right, don't tell me. I'll find out from some one else. But I *will* find out. I'll get by my own efforts the information you withhold from me." In this way they "steal" information out of resentment and spite. They feel guilty about information so acquired: it is forbidden fruit stolen from the tree of knowledge. It must be hidden; they can use it only surreptitiously or in distorted form.

This distorted knowledge is used in fantasies, together with the distorted information passed on by evasive parents. In most cases the adolescent still retains these fantasies and often behaves as though they were true—this even after accurate information has been presented to him—just as children continue to believe that the earth is flat after they have been given evidence of its roundness. The adolescent likewise may continue to seek information assiduously out of spite, and to feel guilty about the quest.

The Optimum Development of Personality

The willingness to learn and the unhampered use of curiosity are not only basic to the free play of the intelligence—the substitution of independent reflective thinking for the acceptance of traditional belief, authority, or prejudice—but contribute also to the optimum development of the individual by permitting him to experiment creatively in new situations and develop a wide range of interests without fears and guilts to inhibit his zestful enjoyment of them. The relation of outgoing attitudes toward people to the personal and social worth of the individual's life needs no elaboration. In other words, the steps which develop desirable characteristics almost by definition promote the worth of the individual.

But it should be made clear in passing that neither the infantile origins of adolescents' attitudes and interests nor the childish level on which they frequently find expression detract from their worth. It is only when an adolescent's interest in science, for example, remains on the level of thwarted curiosity or resentment, only when he continues to use his environment for his extremely personal purposes without respect for its own logic and demands, that growth is interfered with. Only failure to progress from a childish level of expression detracts from the worth of the individual and the social dignity of the interest itself. Some personal quest is basic to all interests. In teaching, attention should be focused on the direction which the interest is taking—away from childish use of the environment and toward an interaction through which both the person and the medium are enriched.

AN ILLUSTRATIVE CASE

Introduction

The foregoing presentation of developmental factors is of necessity dogmatic, fragmentary, schematic, and oversimplified. It fails, for example, to point out the continuous and almost indistinguishable interaction among physical, intellec-

tual, emotional, and environmental factors; neither does it take into account the essential uniqueness of each individual's developmental history. An examination of the case history of a normal adolescent, though the actual guidance was undertaken by a trained worker and not by a teacher, may contribute to a realizing sense of the subtle complexity involved.

Harold as the School Knew Him

Harold Brown is a boy of sixteen, tall, handsome, very intelligent. He is a senior in high school, a member of the school executive council, very much interested and exceedingly capable in the study of biology, physics, and chemistry. He plans to continue his study of the sciences in college and eventually to study medicine.

Harold's interest in the sciences dates from his tenth year, when he joined a "tree group" at a near-by children's museum. Together with another member of the group, a boy of his own age named Dan, he made a study of all the trees on the block where he lived. Together they constructed a very elaborate map, pasting upon it specimen leaves and detailed descriptions of each tree. Following this, the two boys became very much interested in astronomy, formed a small club of their own, and attempted to read as widely as possible in their new field of interest; they constructed several simple telescopes. Then Harold entered high school and started his study of biology. The subject fascinated him. He read widely outside of the assigned work. He and Dan built a small laboratory for themselves in the basement of the latter's home. They began to read in the field of chemistry. Whatever money they received went to buy chemicals, scientific books, a microscope, and laboratory equipment. Harold succeeded, too, in finding a part-time job after school in a neighborhood drug store. Here he learned something about compounding prescriptions and decided that life would not be worth while until he had finished the language requirements imposed by the high

school and could find time on his program to elect chemistry and physics. In the meantime, he compensated for this lack by attending lectures on scientific subjects whenever opportunity presented itself. He entered a city-wide science contest, submitted an exhibit dealing with milk and vitamins, and was awarded a prize of ten dollars. He spent the money at once for books dealing with science and surgery.

The Science Teacher's Questions about Harold

Here, one might think, was a boy to gladden the heart of any science teacher. But the very intensity of his interest made his science teacher stop to think. Was Harold, in his blind devotion to science, seeing the world, and himself in it, with clarity and in perspective? What use was he making of this driving scientific curiosity? Would continued application to science make him a happier person? Why did the other boys and girls in the class dislike him and avoid him, although they accorded him a certain reluctant admiration for his "cleverness"? Why did he become so upset and moody if the teacher qualified one of his answers?

One day the boy's face had darkened when the teacher reprimanded him good-humoredly for answering questions directed to other students. For the rest of the period he slumped in his seat, sullen and inattentive. The following day the teacher asked the group a question which no one seemed able to answer. Harold approached him with the correct answer after the period. When asked why he had not given the answer in class, he said, "Yesterday you told me I talk too much. I worried about it all night."

Then, too, the teacher knew that Harold had cheated in a recent geometry examination. The mathematics teacher had warned the class against cheating; yet Harold sat in the front row almost displaying a slip of paper on which he had previously written the proof. How could such an intelligent boy behave so stupidly?

When Harold indicated a desire to linger after class to talk, the teacher encouraged him. Given this opportunity and assured of the teacher's interest, Harold spoke freely about himself. Among other things, the teacher learned that the genesis of the boy's interest in science coincided with the death of his mother, which had occurred when he was ten. He had been very closely attached to his mother and very dependent upon her. He was next to the youngest in a family of five boys, with none of whom he got along. The older ones tried to "boss" and dominate him; he was afraid to assert himself in their presence. The youngest quarreled violently with him, and he treated this younger brother exactly as his older brothers treated him. He did not get along well with his father, who did not understand him. The father had remarried several years ago, and Harold did not like his step-mother. He liked her even less, now that she was about to have a child. He seemed to like no one at all, and no one liked him. The other clerks in the drug store teased him unmercifully; his employer was chronically impatient with him. He was sensitive, too, about working in the drug store. He suffered intensely when people whom he knew came in, and he tried, at such times, to escape into the rear of the store.

The quality of his school work had begun to decline; he found it extremely difficult to concentrate. He did not like his classmates, either; they were all rivals, to some of whom he felt very much inferior, to others very much superior. He felt that he was different from other boys, but did not know what to do about it. His health had begun to suffer under the strain; he took headache powders in order to sleep at night. To make things worse, his father had a serious cardiac ailment. He planned to become a physician so that he could help his father. That ambition had first occurred to him when the class had been dissecting a sheep's heart; the experiment had made him think of his father's condition.

The teacher was eager to help this boy, but realized that he himself could not do it directly. He assured Harold that

the guidance worker in the school could assist him in straightening out some of his problems, if he so wished. Harold welcomed the opportunity.

A Guidance Worker's Interpretation of Harold's Development

In the course of his weekly interviews with the guidance worker Harold talked about his family, his friends, his work, and how he felt about them. The interviews, in this case, went on for a long time—well into a second year. During this period the worker discussed her interpretations of the boy's personality in a series of conferences with his subject teachers. She explained that these interpretations were tentative, based on such material as Harold had presented up to that time. They were derived from hypotheses of mental hygiene which had proved useful in the understanding of human behavior.

Here was a boy, she pointed out, born almost sixteen years ago, who, for a time after birth, enjoyed the center of the family stage and a great deal of loving attention from his mother. With the weaning process came the first threat to his absolute security. The child struggled against the loss of that security, refused to take the bottle for several days, and then gave in. His mother, the one person upon whom he had depended completely, seemed suddenly to have become wholly undependable. He felt hostile toward her, turned from her, and against her.

A few months after this trying experience, a new baby was born. The first child not only saw the newcomer enjoying what had been taken from him, but also suffered further neglect in that the mother's time was largely taken up with the demands of the new baby. Harold's hostility toward his mother increased. He tried to get attention from her—to do so by any means. When he was good, his mother could devote more of her attention to the baby; therefore he tried being bad. He struggled against new situations as they arose. He refused to give up his bottle until he was seven years of age, thus forcing his mother to give him the kind of attention he wanted. Simi-

larly, he refused to learn to put on his own clothes. When he should have been out playing with other children, learning how to get along with them, the need for his mother's attention kept him sitting at home near her.

His older brothers and his father, as well as his mother, punished him for his behavior. The boy was miserable, overwhelmed by a mixture of fear and anxiety. What was the matter with him? Why did every one pay so much more attention to the baby than to him? His "badness" could be the only reason. Yes, that was it—he was an inferior kind of person, he was no good. But he was no good in another and more terrible way, too, for there were moments when he wanted to put out of the way—to annihilate—his mother, the baby, and all those who interfered with his getting what he wanted when he wanted it. And he feared the thought that he had wished to destroy those whom he loved.

When Harold was ten years old, his mother died. There had been any number of times when he had wished her out of the way. He had tried to put these wishes out of his mind. But with her death he again felt remorse because of them. As a very small child, Harold, like other children, believed in the efficacy of his wishes. Therefore, he felt in a way partly guilty of his mother's death. His remorse became intolerable. He could not bear the burden of it and tried to shift it to his father who had been included, long ago, in the general extension of his hostility toward other people. After all, it was his father, he suspected, who had been responsible for the coming of the new baby.

When Harold was twelve, his father remarried. To his new step-mother the boy transferred all the hostility which he had felt for his own mother, and very little of the love; at least, he did not want to admit the love, even to himself. It was easier to express his hostility toward the step-mother than it had been toward his own mother. There was not the same conflict involved, because people did not so much expect that he should love her. Indeed, he felt very guilty about the feelings

of love that he occasionally detected in himself for his new mother. He repressed them; they involved him in a frightening rivalry with his father. The feelings of antagonism which arose from this rivalry he again transferred to his father; it was not he who hated his father; it was his father who hated him. Hostility rose higher and higher.

Then he learned that there was to be another child. He felt himself once more back in his very early childhood situation. Harold reacted to it with the same intensity, with even greater intensity, because of his accumulated antagonisms. He, himself, did not recognize the source of his disturbance; he knew only that he was disturbed to a point where he felt incapable of coping with the situation. He tried to hide and deny his resentment, but it grew so strong that it threatened to sweep him off his feet. It was then that he came for help.

Some of the Factors Influencing Harold's Interest in Science

At an early age Harold had already developed feelings of fear and anxiety, of guilt and inferiority, to a high degree. As he grew older, he had new experiences, went to school, met people outside the family group. But the old experience which had pained him so much, and the feelings associated with it, were very much alive. He still had a great need for love and security, still felt the keen pain of his early deprivation. And now, as an adolescent, Harold was no longer conscious of the origin of his pain. He merely knew that he had it. The causes had long been repressed from his consciousness in an attempt to deal with a situation which had been more painful than he could bear.

He had repressed his hostility as well, using self-punishment to dispose of the guilt and remorse which had resulted from it. He had to have some explanation for them, had to know why he felt so guilty. In order to have such a reason, he was "bad." He wanted to have a definite excuse for feeling guilty; he wanted, too, to bring some punishment upon himself, to atone. He was, of course, not conscious of "being bad" or of

doing wrong with this purpose. He did not realize that it was a need for self-punishment which made him cheat in the geometry examination, in order to be punished.

He also used masturbation as part of this "being bad." Now masturbation, the guidance worker pointed out, is a universal practice among small children and reappears in intensified form in most normal adolescents. The added intensity and frequency of it in Harold's case was due to the fact that he used it as something to which he could attach his guilt. He had first masturbated, as do all children, for the physical sensations he derived from it. After masturbating, he felt so extremely guilty that he needed solace. To find it, he turned again to masturbation, thus increasing its frequency.

He had heard the usual stories of the evil results of masturbation, and he believed them. He showed that he felt sexual curiosity to be punishable. He had never forgotten how his father had slapped him over the mouth for asking certain questions. Even recently, when he asked his father where babies came from, the father had replied, "People buy them." He hated his father for his evasions and for the contempt such answers implied. He turned elsewhere for the answers—to science.

But so great were his fear and anxiety in this area that he could not learn, even when the study of biology offered him rich opportunity to satisfy his curiosity. He distorted the knowledge which he obtained in the classroom. He knew, theoretically, how birth took place; yet he still retained, although he laughed at himself for doing so, his childhood belief that babies resulted from eating, and that birth took place through the rectum. (Not until he was freed from some of his guilt and its thwarting effects was he able to accept the facts which he had been so long in seeking.)

His guilt played a similar rôle in his determination to study medicine. He had hated his father for his part in bringing the new baby into the world, for what he conceived to be his father's responsibility in the death of his mother, for the

father's withholding of sex information. As indicated above, his childhood hate had taken the form of wishing to do away with his father. And now his father was very sick. Harold felt guilty, as if his wishes had in truth been somehow responsible for the illness of his father, whom he loved, despite his antagonism. He would atone. He would become a doctor and make him well again. He would get the answers to his questions through science and then use his guilty interest in an attempt to undo the effects of his hostility toward his father. (Of course many other factors determined his choice of medicine as a vocation—among them a desire for prestige to overcome his inferiority.)

Some of the Factors in Harold's Emotional-Social Relationships

Harold's feelings did not affect only his science interests and learnings, however. They expressed themselves as well through the use he made of his intellectual ability, through his attitudes toward himself and others—his classmates and teachers, the guidance worker.

He was well endowed intellectually and soon learned that he could use academic success to offset feelings of inferiority. His search was not so much for knowledge as for some means of overcoming his feelings of distress. He was intrigued by the opportunities which competition in school offered. But in part he was afraid of his academic ambitions, because they entailed rivalry with others, and to him that meant hostility.

So academic success did not serve his purposes effectively. He overcompensated for his feeling of inferiority. He said to himself, "I am brighter than others; I am brighter than anybody else." When reality conflicted with this view of himself, he projected his own inadequacies upon others: "The teacher has a grudge against me. He confuses me with another boy. He does not give me the grades which I deserve. This low mark should have been given to the other fellow." At other times he regressed to more immature behavior; faced by a test in which he had reason to think he would not do particularly

well, he developed a very bad headache and stayed out of school. He rationalized what happened as follows: "That was an easy test. I could have passed it very well, if only I hadn't become sick." Unable to understand the discussion in geometry class, he sat in the room but escaped from the unpleasant situation by day-dreaming. He told the worker that he pressed the point of his compass against his vest, thinking: "How little it would take to kill myself. When I am dead all the people who have failed to understand what a wonderful person I really am will be sorry." At other times his day-dreams took an opposite turn: "Some day I shall discover a cure for cancer —not years from now, but now. I shall be hailed far and wide as the boy prodigy who put an end to one of the world's greatest plagues." He could not bear to admit anything but superiority.

He did not even realize, consciously, his hostility toward others, because he had covered it up with an exaggerated kindliness and consideration. Yet his feelings were quick to be hurt, since he took any criticism as hostility, as an attack, and this reactivated his own hostility of which he was very much afraid. Employers, teachers, other adults, lost their own identities and became for him father, brothers, and mother. He reacted to them and what they did and said in terms of the individuals whom they represented to him, rather than in terms of reality. He transferred his resentment against his father to his employer and some of his teachers. The love which he felt for his father, and which he hardly dared admit to himself, he expressed toward adults who were kind to him, who represented his ideal of a loving, indulgent father. In similar fashion he approached other people with the feelings he had toward his brothers and his step-mother, and endowed these others with their characteristics.

In so far as his hostility toward the members of his family took the form of contempt and scorn, he transferred these, too, to teachers and contemporaries. Many of his teachers and most of his classmates reacted to this hostility with a similar hos-

tility. There was reason for Harold's feeling that he liked no one and was liked by no one in turn. He failed, however, to realize that the attacks were evoked by his own readiness to attack, so thoroughly had he hidden this readiness from himself.

But these outlets for his anger and fear, indirect as they were, and quite devoid of insight or awareness, were not sufficient to take care of the many tensions which Harold had accumulated. His attacks of anger against his younger brother, his verbal attacks upon other people, served to discharge some of his feeling. Much of it, however, he turned against himself. Just as an angry child balls his fists and breathes rapidly, so Harold turned his anger into physical channels. His tensions revealed themselves in a number of physical symptoms for which medical examination showed no organic cause: headaches and difficulties with his vision.

What the Guidance Worker Did

The guidance worker undertook the task of dealing with these problems by constant reassurance, by playing the rôle of the understanding parent whom Harold had not had. Only thus could she go back to the point where the damage to Harold's curiosity had been done and undo it. The boy was constantly in search of such a parent; he needed some one who would understand and help him, some one who would listen to what he had to say without condemnation and without censure. The worker became that person. She determined to let herself be "used"—as mother, father, brother, or in any rôle which might be necessary.

And Harold "used" her. At first, he used her as the fond, protecting parent, bringing his troubles to her, and expecting them to be removed from his own shoulders. Sometimes the worker, feeling it wise to leave with Harold as much responsibility as he could carry without too much difficulty, was not as indulgent as the boy wished. At such times, Harold unloaded upon her much of the resentment and hostility which he felt

for his parents and which he had been afraid to express directly. At first, this expression of hostility was halting and followed by extreme fear: Suppose the guidance worker should stop liking him or should punish him?

This situation caused difficulties for his teachers, too. He had to find some outlet for the hostility which he was afraid to express toward the worker, and he vented it little by little upon his teachers, classmates, employer, and family. It was difficult at times for the teachers to remember that the scorn, the anger, the hostility expressed toward them had really nothing to do with them; that these emotions represented the boy's feelings toward other persons. It was difficult, too, to remember that they were not an indication of lack of appreciation or of genuine dislike. Their discussions with the guidance worker helped a great deal in understanding this.

As time went on, and Harold came to accept the guidance worker's interest in him as genuine and unwavering, as he became convinced that he need fear no punishment, he expressed himself more freely and more honestly, talking about his resentments, his aspirations, and his wishes.

Some of the Resulting Changes in Harold

When his anger and fear had subsided, he was free to see things as they were. He realized for the first time his own part in the daily happenings at home, at school, in the drug store. He lost his fear of his father and was freed to admit and express his genuine liking and understanding. His rivalry with his father and brothers was stripped of its antagonism. He could now turn his energies into constructive competition with his brothers, instead of using them for attack and defense. He worked out, too, his feelings for his step-mother and became very fond of her.

At the same time, as his relationships with parents and brothers improved, he began to make friends among his contemporaries. He learned to dance, began to take girls out, to enjoy give and take with others. He found, too, that his em-

ployer at the drug store was not as cantankerous as he had thought him. His teachers seemed to like him much better.

His work in all subject areas improved remarkably so that he excelled even in the field of foreign languages in which he had previously been deficient. He was able to direct his energies into constructive competition with others—and therefore to achieve more easily and successfully. He had, as he himself said, ceased to be afraid of the world, ceased to think of it as a dark, murky place in which untold dangers lurked. He realized the difficulties and obstacles which reality placed in his way, but felt now that he both wanted and was able to face those difficulties and devise ways to surmount them, instead of giving up hopelessly or running away.

And what happened to his science interest? In this particular case, that interest increased after the resentment and fear underlying it had been removed. It was no longer stuck on a childish level; he was free to progress in a direction which enabled him to use it on its own terms for purposes of more genuine worth to himself. Previously his interest in science had been largely an attempt to find the answers to his childhood questions about sex. Because of his guilt, he had never been able to accept and make use of the answers science offered. He asked and refused the answers. All his questions were really the same question; there was but one facet to his interest, and one which could not be satisfied. Now, freed to accept the answer, he could turn to other questions, make other inquiries, and therefore develop a many-faceted interest in the sciences. Consequently, his interest in the world about him increased, and his relationships with people changed correspondingly. Previously he had been unable to make friends. The amount of time given to science had served as an excuse for not having friends, and so had contributed toward keeping him on a childish social level. He was now able to develop satisfying relationships with fellow-students on the basis of their mutual interests of many kinds.

It should be pointed out, in closing, that these changes did

not take place suddenly. The worker, and the teachers through her, worked with Harold for more than a year. At the beginning, progress was slow; often it seemed that Harold was going backward rather than forward. Occasionally there were sudden favorable manifestations of growth which disappeared as quickly as they had taken place. They reappeared, only to fade away again. And then came the apparently miraculous change; in reality, it was but an indication of the extent to which disturbances in one area of the individual's life affect every part of it. When the fundamental difficulties had been satisfactorily solved, the many other problems, which were but a reflection of those difficulties, likewise disappeared.

THE TEACHER'S RESPONSIBILITY

The argument of this chapter suggests that in the teacher's effort to respect the personalities of his students, kindliness must be supplemented by insight. It is something not to shame the student who is not interested; it is far more to recognize the causes of his indifference and to help him overcome it. It is one thing to accommodate the student who is overdependent; it is far more to know how he came to be so and to help him grow to greater independence of thought and action. Genuine respect for personality lays the responsibility upon the teacher to treat the student in terms of what he may become; to do so requires insight into what he now is and the factors which contributed to his present stage of development, to see the classroom situation as a whole in its meaning to the adolescent, and to recognize the teacher as an important part of that situation.

Seeing Classroom Behavior as a Clue to the Whole Personality

Every teacher is aware that some of his students shun science like the plague, some do their best to be conscientious about it as a part of their school work, and a very few exhibit an

interest and activity which amount almost to an obsession. He recognizes that some students lean upon him for every move, whereas others proceed more or less successfully under their own steam. Irrelevant and disturbing classroom behavior always accompanies the main business in hand—showing off, tears over minor mishaps and misunderstandings, day-dreaming, petty animosities. None of this is irrelevant to the science teacher seriously concerned with helping his students order their living more effectively. For it is through the whole of the student's behavior toward science, toward the other members of the class, and toward himself that he will get his clues as to the stage of the student's development and the developmental factors involved.

When lack of interest is regarded from this point of view, it ceases to represent mere recalcitrance to be sternly treated as such and comes to indicate instead some blocking, some reaction to a past which, however irrelevant in a logical sense, still plays its part in the student's feeling reactions to the present situation. When aggressiveness or attention-getting cease to be conceived as annoyances and come to be taken as indexes of what the student is actually attempting to achieve by them, they will become a signpost to the means of their own cure. Even an extreme and gratifying interest in science is better examined in terms of its origins and meaning to the student, lest otherwise it fizzle out or continue to occupy the forefront of his attention without genuine or full reward either to himself or to the scientific problem under study. This is especially true in cases where the student's social adjustment indicates that he has a personal problem. Any attitude assumes meaning and significance only so far as it is brought into relationship with other expressions of personality, and both lack of interest in science and obsession with it become symptomatic only when they are brought into comparison with the student's relationship to people in his environment.

Seeing the Classroom Situation as a Whole in Its Meaning to the Student

The teacher must come to look upon the total situation in the science classroom in terms of what it means to the student —an opportunity to get attention of which he has been deprived, a situation in which to express his resentment against the way in which his curiosity has been thwarted, a threat lest it encroach upon his personal taboo areas or touch upon his hidden remorse, a new group of persons among whom he has to make his way, another place in which to succeed or fail, another teacher to replace the forbidding or cherishing parent. If science is to play its proper rôle in education, the teacher will have to adopt this situation in terms of these most intimate and immediate (if oftentimes irrational and unanticipated) meanings which it has to the student.

For the student is not merely studying science. He is likewise associating with his fellows, developing relationships with them and with the teacher. Subjects of study, school and classroom attitudes and values, the configuration of feelings within the particular student group, the appearance, manner, and characteristic ways of the teacher all play their part. The student as a whole and functioning personality is reacting to a whole and dynamic situation, and not to one factor in it alone.

Recognizing the Teacher as an Important Part of the Whole Learning Situation

The teacher must come to recognize himself as a part of the total situation to which the student reacts and to adapt his own behavior accordingly. Earlier sections of this chapter have called attention to the way in which he stands as parent surrogate to the adolescent. This understanding will make it easier to treat the student's scorn, contempt, and hostility with far greater objectivity. If he finds the student dependent upon him, unable to make a next step without consultation, accepting his word for law, and using him ruthlessly without regard for his time, energy, or inclination, he will find in that situa-

tion a challenge to understand the impelling motives and to adapt his behavior to insure growth.

Once the teacher recognizes that he himself is a factor in the student's situation, he must assess his own development and motives. Is he, in fact, capable of adapting his behavior so as to help the student outgrow his present stage of development, or does he, too, have a wishful stake in the situation? Does he, perchance, enjoy the dependence which some students show toward him too much to give it up? Does he like the authoritative rôle? Can he resist meeting hostility with hostility, lack of interest with sarcasm? What personal satisfaction is he seeking in the classroom, and is it objective and legitimate? Increasing insight into the student's reactions is not enough; the teacher must also become aware of himself if the pupil-teacher relationship is to eventuate in genuine growth. In most instances the teacher will be able to make this accounting for himself; on occasion he will require expert help to gain the requisite insight into his own classroom behavior.

Account must also be taken of certain universal dangers and pressures in the teacher's background. The science teacher usually comes to his work well grounded in the particular sciences he is to teach—and with vague fears and misgivings about the young people who are to be his students. He has the satisfaction of feeling sure about his factual knowledge, but he has had no systematic training in the understanding of boys and girls. He is left to acquire such training on the job, and through his own efforts. With this background it is inevitable that he should at first consider the imparting of subject-matter the very essence of his work. Supervisors tend to measure his success in these terms. The student's disinterest in science, his inability to achieve, may therefore become a personal affront, a genuine threat.

In his previous educational experiences, the teacher has found it sufficient to achieve in his own person, and this has been relatively easy, since achievement then depended upon

himself alone. But now he finds himself in a different situation, one in which his success is dependent upon arousing such efforts not within himself, but within other persons. It is as if he were asked to control some one else's foot movements, to direct them as easily and efficiently as he does his own. If the student insists upon going his own way, if he does not develop interest and proficiency in the sciences, the teacher is likely to feel himself a failure in his own eyes and in those of his superiors.

According to the point of view here presented, the teacher must regard the student as a being quite separate from himself and must be sufficiently free from the pressures of his own background and immediate situation to permit the student to find his own way without affront, without frustration, without sense of failure. The interest and ability of the student in the sciences are but a means to his total development. If they are to be effective, they must be interpreted in terms of the student's background and pressures, not those of the teacher. And the teacher must become sufficiently objective so to regard them. Such objectivity will contribute to the genuine success of the teacher in the terms of this report.

Gaining Insight

The present chapter has provided no prescriptions and no rules of procedure. Its argument should have made clear that there are no rules, that procedure must be determined by the specific situation. Teachers with insight know what to do. The task before the teacher then becomes the development of insight, rather than learning prescriptions of what to do in the face of this or that classroom event.

One of the best ways of acquiring insight is represented by the teacher's procedures in the case of Harold Brown. The intensive study of one individual, made with a guidance worker's assistance, increased his sensitivity to the feelings and problems of all the students in his classes. It also gave him added understanding of his own behavior in the classroom. He came

to recognize that some of his strongest reactions to a number of students were based upon the fact that he saw in them certain of his own faults and, like every one else, found it easier to criticize others than to face the faults within himself. Correlatively, he tended to favor given students because they had the abilities and attitudes which he liked best in his own personality make-up.

He observed himself developing greater tolerance toward students whose abilities differed from his own; came to feel that "different" did not necessarily mean "inferior." He felt annoyance much less frequently in the classroom. The realization that a certain student was "asking for punishment," that the impertinent and disagreeable student needed help in understanding his behavior, rather than censure for it; that the student was frequently as much troubled by his behavior as was the teacher; that such behavior often represented not so much a reaction to him individually as it did to other people in the adolescent's family—all this made it easier for him to adapt his behavior appropriately.

In the absence of a guidance worker the teacher will be obliged to seek other training opportunities. He may find these in experts on the staffs of community agencies, in courses, and in books. Observations of students in terms of points of view gained from reading often prove richly rewarding in themselves.

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IX

EVALUATION OF STUDENT ACHIEVEMENT AND OF CURRICULAR ACTIVITIES IN THE SCIENCE PROGRAM

THE FUNCTION OF AN EVALUATION PROGRAM

The Committee has stated and documented its belief that the function of science teaching is to provide rich and meaningful experiences in the basic aspects of living, so directed as to promote the fullest possible realization of personal potentialities and the most effective participation in a democratic society. Achievement of this purpose means that students progress in the development of certain desirable characteristics of personality and that these manifest themselves increasingly in their conduct in the basic aspects of living. The understandings which students develop through their science experience are supposed to provide at least a partial means by which growth in desirable characteristics may be made functionally effective in social participation.

How shall the teacher find out to what degree his students are achieving growth toward desirable characteristics of personality and growth in understanding? That is the problem of evaluation. Since the Committee has suggested the objectives of general education as well as ways and means for achieving them through instruction in science, it is under some obligation to suggest methods of evaluating students' progress toward them. The purposes of this chapter are to suggest a point of view on evaluation which is consistent with the philosophy of education implicit in this report, stimulate science teachers to a consideration of evaluation problems, demonstrate the interrelationships and interactions of evalu-

ation and educational objectives, and recommend selected references for further reading.

The interpretation of a given change in behavior as even partly the result of a given educational experience must be based upon some explicit and consistent theory of the structure and motivation of human personality and conduct; otherwise there is great danger that false or inadequate conclusions may be drawn. But the point of view on the nature of the individual sketched in this report confronts the evaluator with a series of dilemmas. The oneness of the individual and the interrelatedness of the intellectual, emotional, and physical aspects of his personality have been emphasized; it has been pointed out that an emotional conflict may influence intellectual behavior, and so on through all the possible interrelations of physical, intellectual, emotional, and environmental factors. This conception in itself vastly complicates the task of observing and measuring changes in behavior and relating them to educational experiences.

Analysis of the individual's behavior into parts (necessary for objective observation, record, and statistical treatment) precludes taking full account of the unity of the personality which is essential for understanding the changes that have taken place and relating them to their causes. Further, the educator who has accepted the theoretical premises of this report believes that the only complete test of the value of educational experience lies in the conduct of the student in real life—both now as an adolescent and later as an adult; he is not sure that a sampling of student behavior in school and test situations provides an adequate basis for evaluation.

On the other hand, it stands to reason that the best protection against vague and irresponsible theorizing in education lies in the objective gathering and interpretation of the facts on changes in behavior that seem to follow upon educational experiences—a program of evaluation. At present there seems to be no other way to find out what actually happens as a result of different educational procedures, and no other practical

basis for a conclusion as to their relative advantages. In addition, an adequate scheme of evaluation would be invaluable in helping the student, his parents, and his teachers to gauge his achievements and to guide his progress.

Recognizing the definite limitations of any practical program of evaluation in terms of its own educational philosophy, then, the Committee proposes that an evaluation program be developed to provide as many advantages as may be reasonably anticipated, and that it be used with full cognizance of its shortcomings. Such a program must provide a scheme of evaluation that takes account of the "intangibles" of education—that gets real evidence concerning students' progress in the development of desirable characteristics of personality.

First, to be at all acceptable from the point of view of this report, evaluation must be a continuing process. Most significant changes in behavior—surely those which indicate development in desirable characteristics of the personality—take place slowly and need to be observed over long periods of time. Too often it is assumed that the work of each year, or of each semester, is to be judged solely in terms of the outcomes at the end of that period. The fact that the student's development continues throughout life is disregarded. A complete evaluation of the effects that experiences in science have had on a student would involve a continuous study of his personality and conduct and a cumulative record of his development through the years of formal schooling and on into adult life. Though such a program may not be practicable, a close approach to it during the years of formal education can be made.

Second, in as far as possible, the whole and functioning person must be taken into account. Evaluation inevitably consists in taking samples of student behavior and synthesizing them into a picture of the whole personality of a student and of the ways in which it is developing. Where the samples are of separate traits, as they are in a scheme that uses only examinations of limited types, or where cross-sections are few

and far between, the resulting evaluation is of necessity incomplete, one-sided, and to a degree false. But where the samples are cross-sectional in nature, and these cross-sections are plentiful, well placed in the various aspects of behavior, and repeated as time passes, the picture of the student that results may be a relatively faithful reproduction of a living, growing person. Constructing such a picture from cross-sectional analyses is an art which goes far beyond the adding of test scores.

TECHNIQUES OF EVALUATION

Since the general purpose of any course of instruction is to bring about changes in behavior [1] which tend in the direction of educational objectives, the teacher will do well to define his objectives in terms of students' behavior (or changes in behavior) and to devise means of observing and recording behavior (or changes in behavior). This means, for the science teacher, that he must define the behavior by which his students consistently and effectively exhibit progress toward desirable characteristics of personality, and by which they make manifest the degree to which the understandings of the science curriculum actually function in their conduct.

But it is to be noted that the general objectives of education do not represent fixed points to be reached by all students, but rather directions in which all students may profitably progress. Individuals differ not only in rate and methods of learning but in interests, needs, and abilities. How far each student may be expected to progress toward any objective varies with his needs, his interests, and such of his abilities as are involved. Some students will go far in some directions, while others will make greater progress in others.

[1] The terms *desired outcomes* and *desired changes in behavior* are used synonymously. The term *behavior* is used in the broad sense to mean activities which are at once mental, physical, social, and emotional in character.

Each student's pattern of goals is distinctly individual, and any program of evaluation must consider his progress in terms appropriate to him.

To discover the forms and degrees of progress appropriate for any individual student it is necessary to secure his help in stating and revising his goals in the light of continually accumulating evidence concerning his needs, abilities, and achievements. It must be remembered, too, that evaluation is bound to influence the student, whether conducted by means of teacher-made and teacher-imposed examinations that appear as obstacles in his path, or by means of measures accepted or chosen and perhaps partly developed by himself as aids toward the achievement of his own purposes.

To devise an evaluation program which gets information concerning student progress toward all of the objectives of general education is a much more complex task than most teachers have conceived. It clearly cannot be accomplished with paper and pencil tests alone, and evidence that a student has acquired information does not constitute evidence that he has made progress toward desirable characteristics of personality at the same time. The obvious difficulty has led many people to say that satisfactory means of evaluating progress toward the "intangible" objectives of education can never be developed. But whereas not all progress toward the achievement of all educational objectives can be described in terms of observable behavior and evaluated at the time of learning, R. W. Tyler [2] and other workers in the field of evaluation have made an important contribution in devising

[2] In writing this chapter, the Committee has made use of published and unpublished writings of Professor R. W. Tyler of The Ohio State University and of Professor Oscar K. Buros of Rutgers University: R. W. Tyler, *Constructing Achievement Tests* (Columbus, Ohio, The Ohio State University, 1934); Herbert E. Hawkes and others, editors, *The Construction and Use of Achievement Examinations* (Boston, Houghton Mifflin Co., 1936), Chapter I, "Identification and Definition of the Objectives to be Measured," R. W. Tyler; *Educational Diagnosis, Thirty-Fourth Yearbook* of the National Society for the Study of Education (Bloomington, Ill., Public School Publishing Co., 1935), Chapter VII, "Elements of Diagnosis," R. W. Tyler, and Chapter VIII, "Techniques of Diagnosis," L. J. Brueckner.

means to gain objective evidence of changes in student behavior that indicate progress toward such educational objectives as those described in Chapter II.

A general technique for the construction of instruments of evaluation is suggested by Tyler.[3] In simplified form, it consists of the following three steps:

1. *Statement by the teacher of his objectives.* This is necessary in order to indicate what is to be evaluated and to define the variety of instruments of evaluation necessary for comprehensive measurement of student achievement. These educational objectives must be stated definitely and in terms that are helpful in the second step of the process (a surprisingly difficult task).
2. *Description of the kinds of student behavior that indicate growth toward achievement of these objectives.* This requires the definition of specific types of situations in which students will reveal achievement or lack of it. It differs radically from analysis of the content of a course, since it defines the uses students are expected to make of this content. For example, one type of student behavior indicates memory of facts given in the biology textbook, but quite a different type of student behavior reveals the ability to interpret these facts. Thus the kinds of behavior taken as indexes of achievement must be accurately gauged in terms of the particular objectives of the course.

   These first two steps in the evaluation procedure depend primarily upon the teacher, who cannot receive much help in them from the technician in test construction. The technician's principal contribution appears at the third step.
3. *Invention of methods of observing and recording the behavior that indicates progress toward achievement of objectives.* This step can be subdivided into many technical procedures, such as determining the reliability of tests and discovering easily observable things that always accompany significant behavior and may be used as indexes that stand for such behavior.

Most of the remainder of this chapter deals with methods of observing and recording the kinds of student behavior that

[3] *Ibid.*

indicate progress toward achievement of the objectives of science teaching.

It is quite clear that written examinations, whether of the essay type or of the objective or "new" type, are not adequate for obtaining all the evidence on the basis of which evaluation should be made. Other methods will also be required; some of these are:

Anecdotal records by teachers, parents, and students.[4] The anecdotal record consists of an objective description of a significant student reaction and of the setting in which the reaction took place. This procedure promises to develop into a good, practicable means of evaluating progress toward the less tangible objectives of education.

Records by trained observers.[5] This is a rather specialized method, probably most useful for research purposes.

Questionnaires.

Interviews.

Study of student creative products (writing, art products, etc.). This procedure is probably more useful as a means of diagnosing student needs and interests than as a measurement of student achievement.

Students' diaries of reading and other activities. A student record of free reading is a particularly valuable basis for coöperation between teacher and student in a program of student self-evaluation.

Some or all of these methods have proved more useful in measuring progress toward the "non-informational" objec-

[4] Louis Raths, "Anecdotal Records," Progressive Education Association, Evaluation in the Eight Year Study, *Bulletin* No. 1, University of Chicago, September, 1935 (originally published at The Ohio State University); J. A. Randall, "The Anecdotal Behavior Journal," *Progressive Education,* Vol. 13, January, 1936, pp. 21–26. Synonymous terms used by various workers are: observational record, behavior episode, behaviorgram, behavior specific, sentence description.

[5] Willard C. Olsen and Elizabeth Mecham Cunningham, "Time-sampling Techniques," *Child Development,* Vol. 5, March, 1934, pp. 41–58; J. Wayne Wrightstone, "An Instrument for Measuring Group Discussion and Planning," *Journal of Educational Research,* Vol. 27, May, 1934, pp. 641–650.

tives of science teaching than many of the paper and pencil examinations now commonly employed. In general these latter measure chiefly informational outcomes, and though it might seem reasonable to suppose that desired non-informational outcomes always accompany informational ones—that is, that the student who learns the facts of the curriculum well is sure to progress satisfactorily toward the other objectives of education—there is considerable evidence to the contrary.[6] There is probably a positive correlation, but a low one, between memory of the facts studied in a course and growth in such non-informational qualities as ability to draw inferences from given facts or ability to apply generalizations to new situations.

The position of the Committee with reference to methods of evaluating progress toward the objectives of science teaching may be summarized in the following two propositions:

1. Relatively less attention should be paid to conventional paper and pencil examinations, and more consideration should be given to other techniques, such as observational records, anecdotal records, personal interviews, diaries, and study of students' creative products.
2. Teachers, curriculum specialists, and specialists in the study of adolescents should coöperate with test technicians in devising examinations and other methods of evaluation.

Application of the theory and techniques of evaluation previously described to the development of a program of evaluation in science education involves first defining the kinds of student behavior that constitute progress toward the objectives of science teaching. What does "reflective thinking" mean in terms of changes that science teaching can effect in the behavior of adolescents? The same question must

[6] R. W. Tyler, *Constructing Achievement Tests* (Columbus, Ohio, The Ohio State University, 1934); Charles Hubbard Judd and others, editors, *Education as Cultivation of the Higher Mental Processes* (New York, The Macmillan Co., 1936), Chapter II, "The Relation between Recall and Higher Mental Processes," R. W. Tyler.

be answered for each objective of general education. Answering these questions will probably necessitate breaking down each more general objective into a number of relatively specific types of behavior which can be observed and recorded.

Another problem lies in the attempt to evaluate student progress in understandings related to the generalizations of the science curriculum. These generalizations are worthless as mere intellectualized abstractions. For example, the generalization, "the universe is in process of evolution" should not be merely an inert idea in the mind of the student, but something with which and within which reflective thinking and a world picture are developing. Thus there is danger in separating understanding of a generalization from desirable characteristics of personality for purposes of evaluation; however, there are practical advantages to evaluating progress in depth and meaning of understandings separately from, or as a step in, progress toward these characteristics.

Consequently, for the teacher of natural sciences the task of evaluation consists of observing and recording (*a*) progress in achieving the understandings related to generalizations, and (*b*) progress toward the desirable characteristics of personality as they are exhibited in the basic aspects of living, and overlapping of these two aspects of evaluation is to be expected.

EVALUATION OF STUDENTS' GROWTH IN DESIRABLE CHARACTERISTICS OF PERSONALITY

Reflective Thinking

Many of the abilities involved in reflective thinking[7] are of major concern to science teachers and attempts have been made to design instruments of evaluation giving evidence

[7] For a complete analysis of these abilities see Chapter VII. For a summary of recent work in this connection see *Educational Diagnosis, Thirty-Fourth Yearbook* of the National Society for the Study of Education (Bloomington, Ill., Public School Publishing Co., 1935), Chapter XVI, "Diagnosis and Remedial Treatment in the Field of Science," F. D. Curtis.

of student development along these lines. Some of the more promising techniques already developed are described below, together with suggestions that may point the way toward promising fields for research.

1. *Ability to discover and define problems.* Anecdotal records furnish an efficient technique for accumulating evidence on a student's application of this ability in natural situations. Field trips, class discussions, and informal conversations both within and outside the classroom will provide examples. The questions students ask and their comments relative to observed facts are often very illuminating in disclosing a sensitivity to problem situations. Frutchey and Tyler [8] illustrate by an incident from a field trip by a biology class.

> . . . On a recent field trip in the spring the pupils in a biology class saw a number of forsythia bushes in full bloom. As it happened, all of the blossoms were on the lower branches of the bushes; none had developed on the upper branches. Several of the students noted this fact, but only two raised the question, "Why are all the blossoms on the lower branches?" . . . One of the students carried his questioning still further. "Are all forsythia blossoms on lower branches? Have the lower branches been protected from the recent cold weather?" . . . This illustrates the ability to define some of the more specific questions which need to be answered in order to solve the more general problem.

In the classroom the essay test may be used to obtain evidence on this ability through the use of such questions as: [9]

> A farmer had a flock of chickens. He noticed that some days he would get many eggs and on other days he would get very few eggs. What information must you have before you can tell why there was this difference?

[8] *The Construction and Use of Achievement Examinations,* Herbert E. Hawkes and others, editors (Boston, Houghton Mifflin Co., 1936), Chapter V, "Examinations in the Natural Sciences," F. P. Frutchey and R. W. Tyler, p. 235.

[9] *Ibid.,* p. 237. (Adapted with slight changes.)

The authors also indicate an objective type test item which states the problem situation and then gives a list of questions that raise problems needing solution before the major problem can be solved. The list includes irrelevant as well as relevant questions, and the student is asked to check the questions relevant to the major problem. The degree of correlation has not as yet been established between results of this objective type of test item and results obtained by the direct method either through essay-type tests or observational records.

2. *Ability to observe phenomena accurately.* Field trips and laboratory periods offer opportunity for anecdotal records on the ability to observe. Demonstrations performed by either teacher or student call for skill in observation on the part of students. A little training greatly increases this skill. Paper and pencil tests in which the test item consists of a diagram of the apparatus with which the teacher demonstrates an experiment and is followed by a series of questions testing apparatus construction and sequence of procedure can be used to collect evidence. Such test items, used as class exercises, serve as excellent teaching devices. The following illustration was developed in the biology department of Central High School, Tulsa.

A Study of Our Ability to Observe [10]

Part A

Directions:

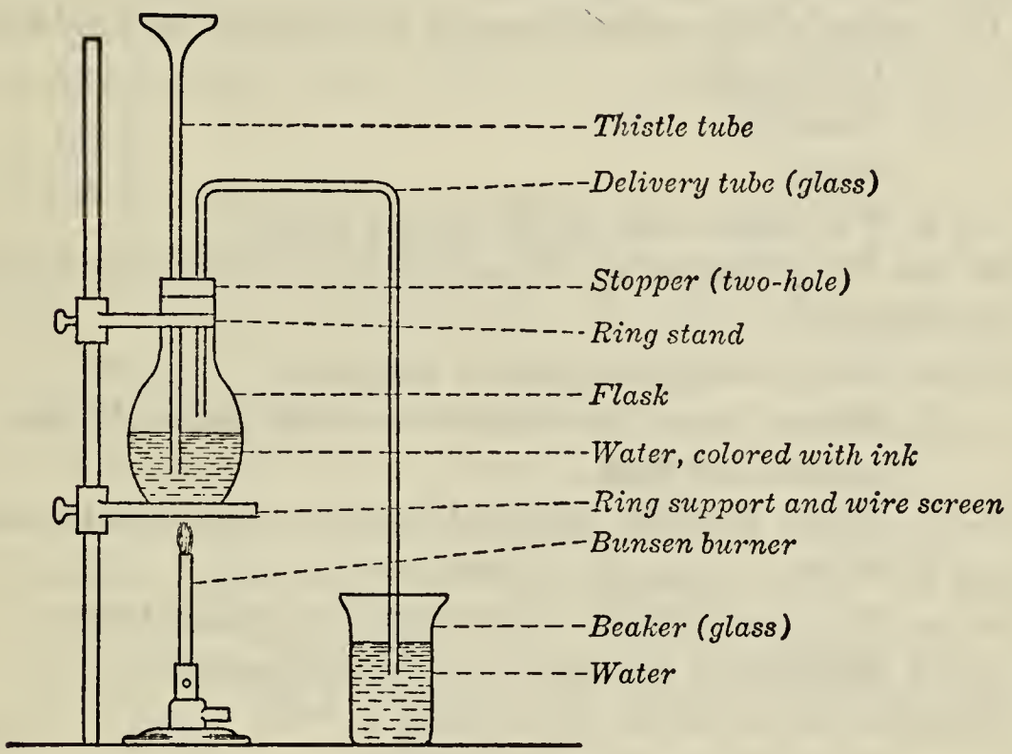
I. At the beginning of this exercise give the class the following oral instruction:

People are often said to be observant or unobservant. Such a description usually refers to that characteristic of an indi-

[10] Central High School, Tulsa, Oklahoma. Under direction of the Evaluation Staff of the Progressive Education Association, Commission on the Relation of School and College.

vidual to be conscious of what is happening about him and what goes on in happenings or situations which he meets. I wish to study with you your ability to see what goes on in an incident or situation. I am going to set up a simple sort of apparatus and with it perform a sample demonstration. Each of you is to watch carefully to see what I do and exactly what happens during the demonstration. After I have completed the demonstration you will be given an opportunity to write down the different things which I did and which took place during the demonstration.

II. Without further comment set up the apparatus in the manner indicated by the following sketch. Be sure to make the "set-up" exactly as indicated in order that the questions put to students, following the demonstration, will be relevant.



III. Apply heat to the flask and allow the solution to *boil* for 3 minutes.

IV. 1. Remove the beaker containing the water.
2. Remove the flame.
3. Remove the stopper, with thistle tube and delivery tube attached, from the flask.
4. Remove the flask from the stand and pour out the liquid.

V. Distribute Part B of this exercise to the students.
VI. Collect Part B. Tabulate the results, in histogram form, and use this tabulation as a basis for class discussion.

Part B

DIRECTIONS: Under each of the partial statements that are listed below, check every phrase which will complete that statement correctly.

I. After the liquid had boiled for some time the water in the beaker:
   — *a.* Began to boil.
   — *b.* Became slightly colored.
   — *c.* Was unchanged in color.
   — *d.* Decreased in amount.
II. The steam which passed through the glass delivery tube was:
   — *a.* Light grey.
   — *b.* Colorless.
   — *c.* White.
   — *d.* The same color as the boiling liquid.
III. At the beginning of the demonstration before the water began to boil:
   — *a.* Tiny bubbles formed in the flask.
   — *b.* Water from the beaker traveled through the tube toward the flask.
   — *c.* Drops of water collected on the outside of the tube.
   — *d.* Water rose in the thistle tube.
   — *e.* Air was "sucked in" through the thistle tube.
   — *f.* Bubbles of gas came out of the glass tube.
IV. After the liquid in the flask began to boil:
   — *a.* A noise came from the beaker.
   — *b.* The delivery tube appeared to turn blue.
   — *c.* Water formed in the delivery tube.
   — *d.* The amount of liquid in the flask decreased.
   — *e.* The bottom of the flask became red hot.
   — *f.* Clouds of steam arose from the beaker.
V. The things which the teacher did at the close of the demonstration are listed below. Show the order in which these things were done by numbering them from 1 to 4.

—— The flame was removed.
—— The beaker containing the water was removed.
—— The flask was removed and emptied.
—— The stopper was removed leaving the tubes attached to it.

3. *Ability to select facts relevant to a problem.* This ability can be tested by constructing items in which a large amount of irrelevant information is included along with the relevant data. This device is quite commonly used in testing in mathematics and is applicable in science classes with mathematical material. It can also be used in non-mathematical areas by describing a situation, giving a large amount of data both relevant and irrelevant, stating the problem, and asking the student to list all of the pertinent data. The item can be set up in objective form by following the paragraph description of the situation and statement of the problem with a list of facts, asking the student to check those pertinent to the problem.

4. *Ability to collect and organize facts.* Since facts are not collected or organized except for the purpose of solving a problem, it seems desirable to test the ability to collect facts and to organize information in the setting of a problem situation. As far as possible a test of a single skill, such as the collection of facts, should be given as part of a complete problem, and evidence on achievement of this particular skill subsequently separated out. But separate tests on special skills often have diagnostic value. Tests dealing with three aspects of the ability to collect and organize facts are briefly discussed below.

a. Familiarity with reliable sources of information. Frutchey and Tyler describe a technique suitable for obtaining evidence along this line.[11]

DIRECTIONS: In each of the exercises below, you are to suggest the sources which you think are best for getting information on the

[11] *The Construction and Use of Achievement Examinations, op. cit.,* Chapter V, "Examinations in the Natural Sciences," F. P. Frutchey, and R. W. Tyler, p. 232. (Adapted with slight changes.)

questions given. Be as definite as you can in your suggestions. If you mention a book, magazine, or newspaper, state its name. If you do not know its title, tell how you would find it. If you suggest some other kinds of sources, be just as definite in describing them.

1. Where could you find out about the general principles which help to explain the methods of sending pictures by wire?
2. Where would you expect to find the information which would give you the relative conductivity of iron, copper, silver, and aluminum?

The authors include valuable suggestions on scoring responses to such test items.

The direct-response type of test item described above can be set up in objective form by listing a large number of sources of information in one column and a series of questions in another, and asking students to place the appropriate numbers of sources of information opposite each question.

b. Collection of data. To test for ability in the collection of data, checks need to be made on such skills as:

The use of the card index system of the library
The use of the tables of contents, indexes, and glossaries of books
Reading skills and techniques, including interpretation of graphs, charts, diagrams, etc.

An interesting test designed to obtain evidence of library skills and techniques includes items testing familiarity with standard library organization and with techniques of locating information.[12]

Satisfactory and widely used tests are available to obtain data relative to reading skills and techniques. Such information should be of distinct aid to the teacher of science.

Woody and Vedder [13] have designed a test in two forms on

[12] Lulu Ruth Reed, Test on "The Use of the Library for High School," Chicago Planograph Corporation, 517 S. Jefferson St., Chicago, Ill.

[13] Clifford Woody and Almon Vedder, Test on "The Reading and Construction of Tables and Graphs," Michigan Department of Public Instruction, Lansing, Mich.

the construction and the interpretation of graphs and tables.

c. Organization of data. The direct method is at present the only technique available for diagnosis of this skill. The student may be asked to submit his unorganized data together with his organized reports. It would be more artificial to present a large amount of data and ask the student to organize it. This type of artificial test is used by Woody and Vedder [14] in the tests mentioned above. The sampling is fairly extensive and requires mastery of tabulation and graphing skills for satisfactory responses to the situations described.

5. *Ability to draw inferences from facts.* This ability calls for an interpretation of data already collected, and a testing technique called "Interpretation of Data" has been developed in this area. A bulletin by Hartung gives an interesting discussion of the ability and of ways of testing achievement of it.[15] The following illustration indicates the method.[16]

DIRECTIONS: In each of the following exercises, an experiment is described. Below the description of the experiment are several statements which have been suggested as interpretations of the experiment. Assume that the facts given in the description of the experiment and in the results obtained are correct, then on the basis of *these facts only* consider each statement.

Mark with a 1—every statement which is a reasonable interpretation of the results obtained.

2—every statement which might possibly be true but for which insufficient facts are given to justify the interpretation.

3—every statement which cannot be true because it is contradicted by the results obtained in the experiment.

The sample shows what you are to do.

[14] *Ibid.*

[15] M. L. Hartung, "Interpretation of Data," Progressive Education Association, Evaluation in the Eight Year Study, *Bulletin* No. 3, University of Chicago, October, 1935 (originally published at The Ohio State University).

[16] Taken from Cooperative Chemistry Test, Part II, Cooperative Test Service of the American Council on Education, 500 West 116th St., New York.

Sample: In an experiment some white starch was treated with brown iodine solution. This was done ten times and each time a blue color was formed.

Later some white starch was mixed with saliva. The mixture was left for a time and then it was treated with brown iodine solution. This was done ten times and each time no blue color was formed.

a. The starch was changed to sugar by the action of saliva .....(2) *a.*
b. Saliva digested the starch .....(2) *b.*
c. Starch acted upon the iodine .....(1) *c.*
d. Saliva produced a change in the starch .....(1) *d.*
e. Starch mixed with iodine solution did not turn blue (3) *e.*

An adaptation of the same technique which calls for marking on a five-point scale rather than on a three-point scale as illustrated above, shows a higher degree of validity. Sample questions follow: [17]

Interpretation of Data Test

Directions: In each of the following exercises some test, experiment or situation is described. Below the description you will find several statements which are suggested as possible interpretations of the data. Assume that the facts of the description are accurate. Carefully consider each of the statements and indicate in the columns to the right whether you believe

(1) The evidence is sufficient to make the statement true.
(2) The evidence is sufficient to make the statement false.
(3) The evidence suggests that the statement is probably true.
(4) The evidence suggests that the statement is probably false.
(5) The evidence is insufficient to make a decision concerning the statement.

Problem 1.

Dextrose is an extremely unusual product. It is the sugar of the blood; the fuel that furnishes energy for every muscular effort. It

[17] From a test prepared by the Evaluation Staff of the Progressive Education Association, Commission on the Relation of School and College.

can be injected directly into the blood stream where it is utilized exactly as though it were put there through the regular digestive channels. Dextrose is the final nutritive product of the digestion of all starches and sugars and is the only sugar present in significant quantities in the blood of general circulation. Consequently, when it is taken by mouth it requires no digestive effort and furnishes fuel in a minimum of time. Anhydrous dextrose which is 99.999 per cent pure is now being produced at a cost of less than five cents per pound.

Statements	(1)	(2)	(3)	(4)	(5)
a. Athletes should eat dextrose before engaging in extreme competition					
b. Dextrose is used in building up the muscle and bony structure of the body					
c. Dextrose may be used to feed people who are unable to take any food into their stomachs					
d. Dextrose is an extremely scarce substance					
e. People who eat dextrose are apt to be more nervous than those who do not					
f. It is difficult to produce pure dextrose					
g. Dextrose is easier to digest than any of the other sugars					
h. Doctors find dextrose to be a valuable aid in the treatment of certain disorders					
i. The use of dextrose leads to an excessive amount of waste elimination in the body					
j. Dextrose has a higher fuel value than sucrose (cane sugar)					

Problem 2.

An approximate distribution of energy in the infra-red, visible and ultra-violet portions of the radiation from different sources of light expressed in percentages is shown in the table below:

PERCENTAGE OF ENERGY OF VARIOUS LIGHT SOURCES

	Sunlight	*Carbon Arc*	*Incandescent Lamp*	*Quartz Mercury*
Infra-red (heat).	78	85	90	52
Visible light ..	15	10	9	20
Ultra-violet ...	7	5	1	28

Statements	(1)	(2)	(3)	(4)	(5)
a. Most of the energy of sunlight is available as visible light					
b. The sunlight contains a larger percentage of energy as ultra-violet than does any of the other sources					
c. Less than 10% of the energy furnished by an incandescent lamp is used in giving off visible light.					
d. The quartz mercury arc furnishes a larger percentage of energy as ultra-violet light than does the sun					
e. Most of the energy of all the sources of light listed is given off as heat or infra-red rays					
f. The quartz mercury arc is more effective for health treatments than sunlight					
g. On a cloudy day, the proportion of the total energy in the form of ultra-violet light from sunlight is less than 7%					
h. The temperature of a light source determines to a high degree the percentages of ultra-violet, visible and infra-red					
i. There are many other sources which emit a lower percentage of ultra-violet than the incandescent lamp					

Clark Horton has analyzed student responses in "Interpretation of Data" test items and lists ten types of interpretations commonly made by students. The diagnostic value of such a test is at once evident. By analyzing student responses and recording them on a tabulation sheet opposite the ten types of responses the teacher may readily secure illuminating evidence on student errors.

Interpretation of Data [18]

Classification of Student Responses

1. Interpretations supported by the data
2. Interpretations contradicted by the data
3. Unwarranted extensions of the data by interpolation or extrapolation
4. Teleological explanations
5. Unwarranted conclusions as to cause and effect relationships

[18] Clark Willis Horton, *Achievement Tests in Relation to Objectives in College Botany,* Unpublished Ph.D. Dissertation, Ohio State University, Columbus, Ohio, 1937.

6. Interpreting multiple effects as cause and effect
7. Warranted interpretations but go beyond data given
8. Repetition of data without drawing significant inferences
9. Valid inferences using only part of the data
10. Valid inferences based on all the data

The State Science Committee of Wisconsin [19] has designed a test of "Cause and Effect Relationships" that gives valid evidence on this important aspect of interpretation of data. A list of paired occurrences is given, and students are asked to check, indicating whether:

A. The first is the sole cause of the second.
B. The first is one of a number of contributing causes of the second.
C. The first contributes slightly to the second.
D. Both are results of the same cause.
E. The first bears no causal relationship to the second.

Sample test items

1. The branches of a tree move to and fro; a near-by windmill turns.
2. Heat of sunlight; warmth on earth.
3. A woman dropped a dish on the floor; the dish broke.
4. A fruit can was opened; the fruit in the can spoiled.

The Wisconsin Science Committee has also designed a "Fact-Theory Test" of 103 statements which are to be marked as:

A. Well-established fact
B. Well-established theory
C. Theory questioned by some authorities
D. Popular belief not supported by evidence

Sample test items

1. A disease is a punishment for some particular moral wrong.
2. The pressure of water varies with the depth.

[19] The Science Committee, Wisconsin State Education Association, Madison, Wis.

3. Heating the molecules of air increases their speed.
4. All children who are large and strong for their age are poor in their school work.

A test item under the nature of proof in a test devised by the Evaluation Staff of the Commission on the Relation of School and College gives data on the ability to distinguish between fact and assumption. A sample question follows.[20]

John and Paul got on a see-saw, and some time later Paul noticed that the board would remain perfectly balanced when their feet were not touching the ground. "Look, John," he said, "we must be exactly the same weight."

PART 1. DIRECTIONS: Read each statement below. Is the statement a FACT, or is it an ASSUMPTION? Place a check mark (✓) in the appropriate column *before* the statement.

PART 2. DIRECTIONS: Read over again *only* those statements which you have marked as ASSUMPTIONS. Place a check mark (✓) after those THREE ASSUMPTIONS which are *absolutely necessary* in proving that John and Paul were exactly the same weight. Do not mark more than *three*.

Fact	*Assumption*	*List of Statements*
		a. Paul said, "Look, John, we must be exactly the same weight." ——*a.*
		b. Both boys were the same distance from the place at which the see-saw was balanced. ——*b.*
		c. John and Paul got on a see-saw. ——*c.*
		d. The see-saw balanced when the boys were not on it. ——*d.*
		e. The see-saw balanced perfectly when their feet were not touching the ground. ——*e.*
		f. The boys were the same weight. ——*f.*
		g. If the two boys on a see-saw weigh the same, then the see-saw will balance. ——*g.*
		h. The way they leaned while sitting on the see-saw did not influence the balancing of the board. ——*h.*

[20] From a test prepared by the Evaluation Staff of the Progressive Education Association, Commission on the Relation of School and College.

To the Students:

We have placed check marks in front of each statement which show whether we think the statement is a *fact* or an *assumption.* By "assumption" we mean something that may or may not be true —something that is taken for granted—that is open to doubt—that has not been verified or that has not been stated as a fact. Look at the way we have checked the statements. Do you agree with us? You will notice that we did not check statement (*f*). We think that is a *conclusion* and that it is neither a fact nor an assumption. So we left it blank.

In Part 2 we have checked the three assumptions only that we think "are absolutely necessary" in proving that the boys were of the same weight. We think that *without making* those assumptions, Paul could not come to that conclusion and neither could we.

Are You Learning How to Develop a Logical Proof?

When arguments for or against some proposition are presented in newspapers, magazines, speeches, or textbooks, we often feel that the discussion could have been made more logical. Authors sometimes put in statements that are really unnecessary to prove their point; at other times they leave out important arguments; on still other occasions they arrange their statements in such poor order that the conclusion does not seem to be based on or to grow out of the arguments.

Part 3. Directions: Suppose *you* were describing this experiment in order to prove that John and Paul were exactly the same weight. What are all of the *absolutely necessary* steps in the complete development of the proof? Use as many of the above statements as are *necessary,* and place the letters of these statements in their proper order on the line below. Do not use any unnecessary statements.

d, c, b, e, h, f

We think that the statements arranged in this order would make

a good proof that the boys weighed the same. Do you agree? Or do you think some statements should be added or taken out?

Analysis of the test item above will show that it serves the additional purpose of obtaining evidence on the ability of students to draw valid conclusions from data. (See Parts 2 and 3.) Such test items have much greater value as diagnostic instruments and teaching devices than as devices for ranking students in order of quality of achievement. A student may be shown that he is prone to arrive at a conclusion illogically, that his conclusion is inconsistent with the assumptions he has checked as basic, that he assigns irrelevant statements to positions of importance in his chain of evidence, etc.

Another type of test item describes a situation, presents the results obtained, but provides a limited number of interpretations. The student is asked to mark only two, using (*x*) for the interpretation which is most reasonable, and (*o*) for the one contradicted by the data.[21]

Normally, frogs hibernate in the autumn by burrowing into the bottom of the pond. They emerge from hibernation in the spring. On December 10, five frogs were placed in a tank of water kept at a temperature of 55°F. All of them continued to swim in the water, and none of them burrowed into the mud on the bottom of the tank. On the same date, five other frogs were placed in a tank of water kept at 34°F. All of them went to the bottom and became inactive. On May 3, five other frogs were placed in a tank of water kept at 34°F. All of them went to the bottom of the tank and became inactive. On the same date, five other frogs were placed in a tank of water kept at 55°F. These five remained active and continued to swim around in the water.

a. Frogs will hibernate in the autumn, but they will also hibernate in the spring .....( ) *a.*

b. The hibernation of frogs is a response to the season of the year .....(*o*) *b.*

[21] *The Construction and Use of Achievement Examinations, op. cit.,* Chapter V, "Examinations in the Natural Sciences," F. P. Frutchey and R. W. Tyler, p. 243.

c. The hibernation of frogs is a response to temperature. (*x*) *c.*
d. Frogs become inactive when they hibernate .....( ) *d.*
e. Frogs do not hibernate at 55°F. .....( ) *e.*

6. *Ability to plan experiments and to test hypotheses.* Frutchey and Tyler list two types of exercises of value in diagnosis of the ability to plan experiments and test an hypothesis. A sample question follows.[22]

How can one find out that a certain muscle in a frog's hind leg is an extensor and not a flexor?

It would need to be shown that:
a. The muscle relaxed .....( ) *a.*
b. The leg did not bend when the muscle contracted ....(+) *b.*
c. The leg moved when the muscle contracted .....( ) *c.*
d. Other muscles which were not stimulated did not extend the leg .....( ) *d.*
e. The leg extended when the muscle contracted .....(+) *e.*
f. The muscle is a striated muscle .....( ) *f.*

Procedures which would need to be used:
g. Tie the ends of a muscle dissected from the hind leg of a freshly killed frog to the ends of a hinge .....( ) *g.*
h. Suspend the hind leg of a freshly killed frog so that the leg is free to move in both directions .....(+) *h.*
i. Stimulate the muscle with an electric current .....(+) *i.*
j. Examine the dissected muscle under a microscope ....( ) *j.*

7. *Ability to apply facts and principles to new situations.* Three bulletins on the meaning and application of principles and techniques of testing their applications are useful in this connection.[23]

[22] *Ibid.,* p. 247.

[23] F. P. Frutchey, "Application of Principles"; Louis E. Raths, "Application of Principles"; A. N. Zechiel, "Testing Application of Principles," Progressive Education Association, Evaluation in the Eight Year Study, *Bulletin* No. 5, and Supplements, University of Chicago, December, 1936 (originally published at The Ohio State University).

This ability is appraised in teacher-made tests and in many commercial tests, but as a rule the items which secure evidence on the ability are not isolated but are mixed with test items on factual knowledge, vocabulary, interpretation of data, and other things, so that it is very difficult to diagnose student ability in application of principles. Another difficulty arises when single test items involve two or more skills or abilities so that they are not reliable indexes of any one; for example, a student may possess a high degree of skill in the application of principles which he knows, but in a given test situation may not know the necessary facts or principles required. Failure on such an item does not indicate low ability. In cases like this a second test becomes necessary, namely, a test involving only the specific information required in the first. A student rating high on the latter and low on the former may then be judged low in ability to apply principles.

Hendricks, Tyler, and Frutchey [24] give two ways to get at the student's ability to apply principles:

1. Asking the student to explain why a *given* result is obtained in a specific situation; for example, "A steel knife-blade is magnetized and attracts iron objects. Explain why, if the blade is dissolved in hydrochloric acid, the solution is not magnetic."
2. Asking the student to predict the probable outcome and also explain this prediction by using appropriate principles; for example, "A steel knife-blade is magnetized and attracts iron objects. It is then dissolved in hydrochloric acid. Will the solution be magnetic and why?"

In addition to testing ability to apply principles, the examples found in the article quoted above test one other aspect of student behavior, namely, knowledge of the required principles. Throughout the present discussion ability to apply principles will be considered as including:

[24] B. C. Hendricks, R. W. Tyler, and F. P. Frutchey, "Testing Ability to Apply Chemical Principles," *Journal of Chemical Education,* Vol. 11, November, 1934, pp. 611–613. (Adapted with changes.)

1. Knowledge of principles
2. Ability to apply principles
   a. In explaining a given result
   b. In predicting and explaining a probable outcome

Various Ways of Testing Applications of Principles

I. Essay Test Form

A gas company supplies a community with fuel containing hydrogen, methane, and benzene. What will be the names of the probable compounds obtained in the combustion of the gas?

This test item becomes a test of the ability to apply principles when the following conditions have been checked:

1. The student knows the composition of the three gases. (fact)
2. The student knows the composition of air. (fact)
3. The student knows that carbon and hydrogen are oxidizable. (fact)
4. The student knows the nature of combustion. (principle)
5. The student knows that many compounds decompose during chemical action, the constituent elements then entering new combinations. (principle)
6. The situation is new to the student so that a memory response is impossible.

To be sure that the student is using principles in making his prediction, the test may include an additional request, namely, "State the reasons for your prediction." A student answering the question correctly can now be rated as: knowing the necessary facts, understanding the principles being tested, and possessing skill in the ability to apply principles. However, a student may fail to answer the question correctly because of a lack of knowledge of factual material; hence, if evidence on the ability to apply principles is desired, further testing on information is necessary.

To meet this criticism, the question may be further refined as follows:

A gas company provides a community with fuel gas having the composition:

Hydrogen (H_2)	0.9%
Methane (CH_4)	89.5%
Benzene (C_6H_6)	9.3%
Non-burning gases	0.3%
Total	100.0%

What are the names of the probable compounds obtained in the combustion of this fuel with air (21% oxygen, 79% inert gases and water vapor)? State the reasons for your predictions.

The testing range has now been narrowed to the areas defined under the application of principles: (1) knowledge of the principles involved and (2) ability to apply principles. (The information relative to composition of the fuel and of air has been supplied in the question.)

There is still a difficulty in the method of marking this question, however: the scoring is largely subjective and may therefore be open to wide variations among different teachers. This difficulty can be largely eliminated by analysis of the question, by clarifying the objective, and by setting up specifications for a scoring key.[25]

II. Multiple Pattern Test Form

Initial attempts to use objective types of tests for appraising application of principles did not give results consistent with those obtained by the direct method outlined above. Of the several common types of objective tests tried, a special type of multiple response test offered greatest promise. This type has been refined and expanded into a form which does

[25] *The Construction and Use of Achievement Examinations, op. cit.,* Chapter V, "Examinations in the Natural Sciences," F. P. Frutchey and R. W. Tyler.

give a high correlation (.90 or above) with the direct (essay type questions) method as outlined; that is to say, the relative success of each student on the modified multiple-response test is very similar to his relative success on the direct essay type test.

DIRECTIONS: [26] In each of the following exercises a problem is given. Below each problem are two lists of statements. The first list contains statements which can be used to answer the problem. On the blank line to the left of these statements, check only the statement or statements which can be used to answer the problem. The second list contains statements which can be used to explain the *right* answers. On the blank line to the left of these statements check only the statement or statements which *give the reasons for the right answers.* Some of the other statements are true but do not explain the right answers. *Do not check these items.* In doing these exercises, then, you are to check only the statements which *answer the problem* and which *give the reasons for the right answers.*

Example I.

A gas company supplies a community with fuel having the composition:

Hydrogen (H_2)	0.9%
Methane (CH_4)	89.5%
Benzene (C_6H_6)	9.3%
Non-burning gases	0.3%
Total	100.0%

What will be the names of the probable compound or compounds formed in the combustion of this fuel with ordinary air (21% oxygen, 79% inert gases and water), *and why?*

—— *a.* Hydrogen oxide
—— *b.* Methane oxide

[26] These directions and Examples I and II are adapted from tests prepared by the Evaluation Staff of the Progressive Education Association, Commission on the Relation of School and College. Example III is from "A Source Unit in Genetics," by Gertrude Wylie Diederich. See Appendix, p. 524.

— *c.* Carbon dioxide
— *d.* Benzene oxide
— *e.* Water
— *f.* Methanol
— *g.* Benzol

Select and check the following statements which give reasons for the predictions you checked above:

— *h.* In a physical change there is no change in the composition of a compound.
— *i.* Compounds of oxygen and another element are called oxides of that element.
— *j.* Compounds burn more readily than elements.
— *k.* Many chemical changes take place with the evolution of heat and light.
— *l.* Benzol is the common name for benzene oxide.
— *m.* Water is the common name for hydrogen oxide.
— *n.* When compounds unite with oxygen to form compounds, they are called oxides of that compound.
— *o.* When elements burn they unite with oxygen to form compounds called oxides of the elements.
— *p.* Compounds once formed never decompose during a chemical action but act as units in combining with other elements or compounds.
— *q.* Water is often used to put out fires.
— *r.* Methanol is the common name for methane oxide.
— *s.* Some compounds decompose during a chemical action, their constituent elements entering into new combinations.
— *t.* Carbon dioxide is used in a common form of fire extinguisher.

Example II.

When an egg is cooked in an open kettle of boiling water on a high mountain, the cooking time is

a. greater than the cooking time at sea level .....( ) *a.*
b. less than the cooking time at sea level .....( ) *b.*
c. the same as the cooking time at sea level .....( ) *c.*

Check the statements below which give the reasons or reason for your explanation above.

d. Water boils at the same temperature everywhere ....( ) *d.*
e. Just as automobile radiators boil more frequently and quickly at high altitudes, so eggs will cook more quickly on a high mountain .....( ) *e.*
f. A reduction in the boiling point accompanies a reduction in the pressure above the water .....( ) *f.*
g. A reduction in the cooking temperature calls for an increase in cooking time or an increase in cooking temperature calls for a reduction in cooking time .....( ) *g.*
h. A reduction in air pressure accompanies an increase in altitude .....( ) *h.*
i. The boiling point of the water rises as the pressure above the water becomes less .....( ) *i.*
j. Decreased air pressure on mountain tops decreases the efficiency of fires for cooking purposes .....( ) *j.*

Example III.

Assume that in humans blue eyes are due to a unit factor which is recessive to brown.

Mr. A. has brown eyes, but his mother had blue eyes. Mrs. A. also has brown eyes although her father was blue-eyed. They have three brown-eyed children and are expecting a fourth child.

Check the correct prediction:

—— *a.* The fourth child will certainly be blue-eyed.
—— *b.* The fourth child will certainly be brown-eyed.
—— *c.* The fourth child is more likely to be blue-eyed than he is to be brown-eyed.
—— *d.* The fourth child is more likely to be brown-eyed than he is to be blue-eyed.
—— *e.* The fourth child's chances of blue or brown eyes are even.

Check all the statements below which support your prediction:

—— *f.* Every fourth child is blue-eyed in families where the parents are heterozygous for brown eyes.

—— *g.* If there are three brown-eyed children already, at least one parent is probably homozygous for brown eyes.

—— *h.* If one grandparent on each side has blue eyes, the parents must both be heterozygous for blue eyes.

—— *i.* Since the average ratio of brown eyes to blue eyes is 3 to 1 with heterozygous parents, and since there are already 3 brown-eyed children, the chances are more than even that the next child will be blue-eyed.

—— *j.* With parents of the types stated in the problem each child has a 3 to 1 chance of being brown-eyed, regardless of the eye color of children born before or after.

—— *k.* With parents as given, ordinarily the chance for brown eyes is greater than for blue, but since there already have been three brown-eyed children, the chances of the fourth being blue-eyed are about even.

—— *l.* It is impossible to say definitely which color eyes the fourth child will have.

Experimental results obtained with this form of test when checked against results obtained by the essay test method give extremely high correlations, when scored according to the formula $S = 2r - w$. In this formula S is the pupil's score and r and w the number of his correct and his incorrect responses respectively. His omissions are scored as neither right nor wrong.

Procedure in Designing Questions for "Application of Principles" Test

The technique of building such tests seems difficult at first, but becomes quite easy with even a little practice. The following outline of procedure has been found helpful by several teachers who have used it.

1. Select principles to be tested.
2. Describe a situation requiring the application of the chosen principle or principles.
3. Define the problem (question form).

4. Select the correct predictions and plausible incorrect predictions.

5. Select generalizations and plausible explanations to be used in explaining each of the correct predictions and plausible incorrect predictions. This process is facilitated by taking each prediction in the list and writing the explanations which pupils are known to give for it. When pupils are confronted with the list of explanations, it is possible for them to select the explanations which they have in mind for each prediction they previously checked.

In order to obtain the maximum values from the data collected in such a test, the following summary sheet has been found convenient.[27]

SUMMARY SHEET—APPLICATION OF PRINCIPLES

Part I. The ability to make reasonable predictions in the given problem situations.

	Class Median	*Class Range*
a. How many correct predictions were possible in the test		
b. How many predictions were made		
c. How many of these were correct		

Part II. *A.* The ability to recognize the important reasons that support the correct prediction.

	Class Median	*Class Range*
d. How many correct reasons were included in the total test		
e. How many reasons were checked		
f. How many of these were correct		

Part II. *B.* Analysis of errors made in selecting reasons to support the correct prediction.

[27] Louis E. Raths, "Application of Principles," Progressive Education Association, Evaluation in the Eight Year Study, *Bulletin* No. 5, *op. cit.*

Types of errors	*Number in the Test*	*Number Checked by this Student*	*Class Median*	*Class Range*
1. Technically False Statements				
2. True but Irrelevant Statements				
3. False Analogies				
4. Popular Misconceptions of Truth ..				
5. Assuming the Conclusion				
6. Appealing to False Authority				
7. Statements Involving Ridicule				
Total				

Part III. Directions for computing the numerical score.

1. Number of correct predictions made (See I-*c*) .....——
2. Number of correct reasons checked (See II-*f*) .....——
3. ..... TOTAL CORRECT —— × 2——
4. Number of incorrect predictions
   (Subtract I-*c* from I-*b*) .....——
5. Number of incorrect reasons
   (Subtract II-*f* from II-*e*) .....——
6. ..... TOTAL WRONG —— × 1——
7. The student's score is computed by *subtracting the* TOTAL WRONG answers from 2 *times the* TOTAL CORRECT
   ..... TOTAL SCORE——

Part IV. Summary.

Total Score	*Median of Class*	*Range of Class*	*Rank in Class*	*Number of Students in Class*

Analysis of the data as summarized on this sheet will provide many valuable observations of diagnostic value. For example, a student who tends to check statements which are

"popular misconceptions of truth" may be helped to overcome this weakness if he and his teacher know what his errors are.

8. *Scientific attitudes.* Although it is extremely important to obtain evidence of the possession or development of the attitudes required in the application of the scientific method, there are at present no techniques available to accomplish this except the collection of observational or anecdotal records. It is true that paper and pencil tests which give information on the student's "intellectual possession" of the attitude can be designed, but it cannot be assumed that they indicate how he will exhibit the attitude in his overt behavior.

The type of check sheet that follows may offer a valuable means of simplifying and shortening the time-consuming process of anecdotal records.

Check Sheet for Attitudes

	Student Roster				
Attitude	*A*	*B*	*C*	*D*	*etc.*
1. Active Curiosity					
2. Intellectual Caution					
3. Tolerance					
4. Flexibility in Points of View					
5. Expectation that Scientific Method Will Be Successful					
6. Tendency to See a Problem Through to Completion					
Any others in which a teacher is interested					

It should be noted that only two gradations are possible in the use of such a check sheet: positive (demonstration of the application of the attitude) or negative (absence of the application). Consequently, a single recording has little significance, but a record kept over a considerable period of

time, a half year or more, provides significant information. For example, an increasing proportion of positive marks throughout the year indicates definite growth in the development of scientific attitudes. While the observational record is of interest in connection with behavior exhibited in the science classroom, it also seems desirable to take such a record from other situations such as social-science classes, homeroom discussions, school organization meetings, lunch-table conversations, club meetings.

Science teachers have maintained that one of the chief values in a science course is the development of such attitudes or dispositions as have been listed. If there is no transfer of training into other areas, such a justification for science teaching is inadequate. There is no doubt that practically every science teacher can point out isolated cases of such transfer, but the degree to which transfer of attitudes is general has had little study.

Other Desirable Characteristics of Personality

More has been done toward developing successful methods of evaluating progress in the abilities and attitudes associated with reflective thinking than toward developing methods of evaluating progress in the other desirable characteristics discussed in this report. The following discussion of evaluation in connection with the other desirable characteristics is general, indicating briefly what suggestions there are for practical procedures.

It seems clear that these characteristics—creativeness, esthetic appreciation, social sensitivity, coöperativeness, self-direction, and the like—do not lend themselves readily to evaluation by paper and pencil tests. Anecdotal records, check sheets, student diaries and reading records, interviews, and questionnaires promise usefulness. But first each of the characteristics must be defined in terms of student behavior. The following paragraphs represent a beginning in such a definition for several of the characteristics:

1. *Creativeness.* Science instruction should be rich in opportunity for creative experiences. Many, if not all, of the abilities discussed under "Reflective Thinking"—for example, the ability to set up an hypothesis, to interpret data, to draw generalizations, or to make accurate observations—call for creative ability. Each requires the ability to form associations and to synthesize items of past experience into new combinations.

It is doubtful if a satisfactory paper and pencil test which will give an index of a student's creativeness can be devised. It is possible to test for each of the abilities listed above and possibly several others, but together they would not provide a complete picture, for such tests do not take into account the motive power or drive behind human action.

Anecdotal records offer a means of gaining evidence on a student's *creativeness in action.* Teachers need to be concerned with more than the *possession of* creativeness, for creativeness that is not exercised has little value in the development of the individual or in the betterment of the society in which he functions.

Examination of classroom practices reveals numerous opportunities for the collection of significant anecdotal records of creativeness in action. Designing of apparatus, improving the design of existing or suggested apparatus, formulating experimental procedures in problem-solving, systematic organization of facts so that conclusions become apparent, applying generalizations, asking questions that open up new aspects of a problem, original attacks on a problem, all may be evidences of creative ability.

Check sheets may often be used as a short method of tabulating pertinent anecdotal record material. The various situations both in school and out in which creativeness may be exhibited are listed in a column opposite a class roster, and check marks inserted in a student's column when the behavior is noted. A few minutes at the close of the period or school day suffice to note a dozen or more exhibits of

creative ability. In case evidence on any one specific aspect of creativeness is desired, a situation can be staged and a record made for each student in the class. The results of such a test should be noted as either positive or negative, for it is doubtful whether finer gradations than this have validity. The best that can be done is to note either the presence or absence of such ability in a given situation. It is important to note that for diagnostic purposes negative responses are fully as significant as positive responses. Data on apparent *blind spots* can be as valuable as data on definite strengths.[28]

CREATIVENESS CHECK SHEET

	Student Roster														
Creative Activity	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
Design of Apparatus															
Improvement of Apparatus ..															
Outline of Experiment															
Organization of Material															
Originality in Problem-Solving															
Formulation of Generalizations															
Application of Principles															
Asking Significant Questions ..															
Etc.															

2. *Social sensitivity.* Search of the literature reveals little material of definite help to the science teacher interested in determining the extent to which his instruction is aiding in the development of social sensitivity in his students. To date, the most complete study of this quality of personality has

[28] For a description of the broader aspects of creativeness and discussion of educational and evaluatory procedures, see *Educational Diagnosis, Thirty-Fourth Yearbook* of the National Society for the Study of Education, *op. cit.*, Chapter XXIV, "Diagnosis and Remedial Instruction in Creativeness," Paul T. Rankin.

been made by Hilda Taba and reported in bulletin form.[29] In the section devoted to evaluation, the following techniques are suggested:

A. Observational Records
   1. Of group activities
   2. Of informal conversations
   3. Of controlled situations
   4. Anecdotal records
   5. Selective observation (listing significant behavior under each of the school's major objectives)
B. Records of Written Work
C. Reading Records and Book Reviews
D. Records of Significant Social Activities, Individual Diaries, Time Budgets, etc.
E. Records of Plans for College and Career
F. Staff Reports (where schools issue paragraph reports rather than letter or percentage marks)
G. Case Studies
H. Paper and Pencil Tests

3. *Coöperativeness.* A number of schools have spent considerable effort in collecting evidence on coöperativeness. Several of them have used the "check sheet" (like that suggested in the discussion of creativeness above) to distinct advantage. A list of all the opportunities for coöperative behavior—such as close attention to discussion, courtesy to person speaking, helping other students, cleaning up laboratory desks, and care of the room—is placed opposite a class roster and the items checked for each student.

In all evaluations of this type, care must be taken to see the total picture. It is so easy to be impressed by noncoöperativeness and to take coöperativeness for granted that anecdotal records or check sheets may not give an accurate

[29] Hilda Taba, "Social Sensitivity," Progressive Education Association, Evaluation in the Eight Year Study, *Bulletin* No. 6, University of Chicago, December, 1936 (originally published at The Ohio State University). Available material in this area is as yet of uncertain reliability and validity. The bulletin contains many illustrations of observational and anecdotal records.

picture. Obviously a teacher should not make anecdotal records or use a check sheet when he is feeling disgruntled or depressed. In using such techniques it is often desirable to write a summary of the data obtained in a short paragraph, lay it aside, and review it later with the questions: "Does this give an accurate picture of John or Betty?" "Is this picture a sample of customary behavior, or did Betty and I have a bad day when this record was made?" Again, the record of a single teacher may be of low reliability, but a composite picture from a number of teachers will be more useful.

4. *Intelligent self-direction.* Here reliance must be placed on the observational record. Evidence may be obtained in the science classroom (as well as other classrooms), the laboratory, study rooms, library, and leisure-time activities. The student's record of his use of time over a week or a week-end may be illuminating. A teacher may wish to check such items as:

1. Does he use time efficiently?
2. Does he have clear-cut objectives?
3. Does he have efficient work habits?
4. Has he mastered the necessary working skills or abilities?
5. Does he meet his obligations on time?
6. Is he easily distracted?
7. Does he display originality?

Data collected on other attitudes and abilities will also prove of help in evaluating the degree to which a student possesses the quality of self-direction.

Relation of the Teacher to Parents

At this point it seems wise to enter a warning against a possible misuse of evaluation procedures and results in reports to parents. The causes of the kinds of behavior associated with the desirable characteristics are complex and variable. Evaluation procedures may indicate how the stu-

dent is behaving, but they seldom indicate why. The teacher should understand that simple and direct efforts to improve the student in these characteristics seldom work. Exhortation, the most obvious method, is probably the least effective. Urging the adolescent to be more coöperative, more creative, more self-directive, more actively curious, does no good and may do harm. Yet many parents, if they receive reports on their children's status with respect to such characteristics, immediately resort to exhortation. Therefore the teacher should be extremely careful in reporting to parents. If parents and teachers have worked together in establishing the objectives of the school, in defining these objectives in terms of student behavior, and in studying the causes of behavior and the nature of learning, then teachers may report to parents specifically upon such objectives as the desirable characteristics of personality. But unless there is this kind of cooperation and understanding between teachers and parents, it seems wise for the teacher to use his evaluation procedures for diagnostic purposes, much as a physician does, and to give his reports to parents a more general nature.

EVALUATION OF UNDERSTANDINGS

What changes in a student's behavior occur as he grows in the understandings represented by a given interpretative generalization from the field of science? How can the teacher tell, for example, that a student is growing in his understanding that applications of the sciences increase man's control of energy and materials? The simplest though not necessarily the best way is to ask him some questions about engines, the use of fuels, and synthetic chemistry. But this procedure is open to the objection that the student may have memorized answers to questions he expects to be asked and really have very little understanding of the significance of the applications of the sciences to control of energy and materials. A

proper evaluation procedure should catch this understanding actually functioning in the thought or action of the student and should give some measure of the efficacy with which it is functioning.

Detailed observation and careful recording of a student's behavior for as many hours of the day as possible over a lengthy period of time would probably show him applying a number of the generalizations in the science curriculum more or less effectively in his overt behavior. It would also show him missing opportunities to apply other generalizations in situations where their application could have made him function better. Thus at an enormous cost it would be possible to obtain indubitable evidence of a student's progress in mastering the generalizations of the science curriculum. Obviously, it is desirable that some short cuts be found, and this can be done only by teachers and test technicians working together. Anecdotal records are less costly than complete observational records and probably would be useful for obtaining evidence about students' growth in understanding. In discussing actual measures of progress toward complete understanding it seems wise to think of mastery on successive levels and to distinguish between mere factual knowledge and functioning understanding.

Whether a student knows the facts that enter into the generalizations of the science curriculum can be determined through the use of an objective test with items of the usual types, but the items must be obtained through an analysis of the generalizations that actually form the curriculum. No existing science test is adequate to measure the student's knowledge of the facts that enter into such interpretative generalizations as those presented in this report.

Though it is beyond the scope of this report to deal with the general problem of the construction and use of objective tests, it may be useful to summarize the available methods for evaluating knowledge of the facts concerning a given subject.

Various Ways of Testing Knowledge About a Given Subject [30]

I. Essay Test Form

1. In what ways is modern society mastering its natural resources?
2. Show that the kinds of plants and animals found in a given region are determined in a large measure by soil and climate.
3. Show that the sun is the source of energy obtained from water power.

II. Recall Test Form

1. Name the substances from which plants manufacture their foods.
2. Name four industries whose geographic location has been determined at least partially by:
   a. Availability of raw materials
   b. Availability of power
   c. Availability of labor
   d. Availability of markets

III. Outline Test Form

1. Fill in the following blanks:

Process	*Materials Used*	*Products Formed*	*Plant Structures in Which Process May Take Place*	*Is Energy Liberated, Stored or Unchanged in the Process?*	*If Energy Is Transformed in the Process, What Is the Source of the Energy?*
Photosynthesis ..					
Fat synthesis					
Protein synthesis					
Digestion of starch					
Respiration					
Assimilation					
Cellulose synthesis					

[30] This summary was prepared by the Evaluation Staff of the Progressive Education Association, Commission on the Relation of School and College.

IV. Multiple-Response Test Form

1. Place a check mark after each of the following substances which is used in photosynthesis:

a. Carbon Dioxide	——*a.*	*g.* Proteins	——*g.*
b. Cellulose	——*b.*	*h.* Protoplasm	——*h.*
c. Fats	——*c.*	*i.* Starch	—— *i.*
d. Nitrates	——*d.*	*j.* Sugar	—— *j.*
e. Oxygen	——*e.*	*k.* Sulphates	——*k.*
f. Phosphates	——*f.*	*l.* Water	—— *l.*

V. Completion Test Form

1. In the steel industry centered around Pittsburgh the raw materials used are ———, ———, and ———. The location of the industry in this area was determined partially by large deposits of ——— from which the raw material, ———, is manufactured.
2. The early centering of textile mills in New England was determined by the location of easily available ———. The shifting of this industry to the south has been caused by the availability of ——— and ———.
3. The location of oil refineries around New York and Philadelphia has been determined by the availability of ——— and ———.

VI. Master List Test Form

Directions: In each of the following exercises a person is facing a health problem. The first series of statements (numbered 1, 2, 3, etc.) below are things that the person might do in seeking a solution to his problem. On the next page the series of statements (lettered *a, b, c,* etc.) are reasons for these practices. *Although people differ in individual reactions to health practices, certain general practices are recognized as being good for most people faced with a given situation.*

You are to put a plus (+) in the parentheses after each of the proposed things to do that are recognized as good practice. After you have checked these practices, go on to the list of reasons, and select

those that support your decision. After each practice which you consider good encircle the letter or letters which correspond to the reasons supporting those practices.

Problem 1 [31]

James Bartlett has developed a cold. He does not feel ill, but his nose and throat are somewhat obstructed with secretions from the mucous membrane lining these organs. If he follows the best known techniques caring for this condition, he will:

Practices

1. Increase his food consumption to above the normal amount required for his age and weight until the cold has disappeared ..... ( ) *a b c d e f g h i j k l*
2. Take a cathartic ..... ( ) *a b c d e f g h i j k l*
3. Take aspirin regularly until the symptoms are relieved..... ( ) *a b c d e f g h i j k l*
4. Use a nasal douche or some ephedrine preparation to keep the nasal passages clear ..... ( ) *a b c d e f g h i j k l*
5. Go to bed until the condition has cleared. ..... ( ) *a b c d e f g h i j k l*
6. Have "cold shots" administered by a physician and continue about his regular routine ..... ( ) *a b c d e f g h i j k l*
7. Be careful not to infect others by observing such precautions as sneezing in his handkerchief, avoiding crowds, collecting and burning the secretions from his nose and mouth ..... ( ) *a b c d e f g h i j k l*
8. Avoid overeating but eat a normal amount of well planned and balanced meals ..... ( ) *a b c d e f g h i j k l*

[31] Prepared by H. G. McMullen, Evaluation Staff of the Progressive Education Association, Commission on the Relation of School and College.

9. Go into the gymnasium and take a good "work-out" followed by a warm bath and a cold shower ..... ( ) *a b c d e f g h i j k l*
10. Gargle the throat with an antiseptic. ..... ( ) *a b c d e f g h i j k l*

Reasons

a. It is known to be advisable to "stuff a cold and starve a fever."
b. Preventive inoculations for colds when administered by a physician are recognized as one of the best ways of treating a developing cold.
c. Aspirin is recognized by the medical profession as one of the best prophylactic treatments for colds.
d. Nasal douches containing ephedrine tend to clear the nasal passages and make breathing easier when one has a cold.
e. Rest with proper food and comfortable temperatures will allow the body to build up a general resistance and will supply energy for overcoming a disease.
f. Constipation predisposes to colds, making a cathartic essential to the proper treatment of all colds.
g. Overeating may lead to nasal congestion, and congestion of the nasal passages frequently predisposes a cold.
h. Avoiding undue fatigue will aid greatly in preventing and curing colds.
i. A good sweat helps to rid one of a cold.
j. One has a civic duty to perform in helping to prevent the spread of a disease.
k. Reliable laboratory tests of popular antiseptics have demonstrated them to be of decided value for killing most pathogenic bacteria.
l. Most colds infect the membranes of the throat and the germs causing the infection can be killed by using an antiseptic gargle.

VII. True-False Test Form

Place a + after true statements and a − after false statements.

1. Early steel mills were located near Pittsburgh because abundant supplies of raw materials were

close by..... ——1.
2. Coke obtained from soft coal is used in the manufacture of steel..... ——2.
3. The steel industry did not locate near the Lake Superior iron ore deposits because of climatic conditions ..... ——3.
4. An abundant supply of water power determined the location of steel plants near Pittsburgh..... ——4.

VIII. Equation Test Form

1. Write the equation for the chemical action which takes place in photosynthesis.
2. Write equations for the chemical reactions taking place in the reduction of iron ore.

IX. Cross-Out Test Form

In the following description of photosynthesis cross out the words which make the description untrue, and write the proper words in place of the words crossed out.

1. Photosynthesis is the analysis of starch from the raw materials sugar and water. The process takes place in the roots of plants. The energy is supplied by oxidation.
2. Iron is made by oxidizing iron ore by heating it with soft coal. Impurities are removed from the molten metal by the addition of sand to the other raw materials.

X. Alternative Completion Test Form

Underline the alternative words or phrases in the following sentences which make the statements true.

1. The process by which sugar is manufactured in the plant is called (oxidation, photosynthesis, respiration), and takes place in (roots, stems, leaves). The raw materials used are (starch, water, carbon dioxide, oxygen). The process (releases, requires) energy which is (supplied by, given off) as (heat, sunlight, mechanical energy).

Many of these methods just described and illustrated serve to show a student's mastery of the facts necessary for arriving at an understanding. But the science teacher's concern should

not stop at this point. Understandings are achieved by students through the exercise of reflective thinking and the other characteristics of personality described in Chapter II. It is certain that all the members of a class will not reach the same level of achievement of an understanding and that no student will ever reach what might be called complete mastery.

Paper and pencil tests are quite effective in determining whether a student *can* apply understandings to new situations. The essay-type question is admirably adapted to this purpose, and the objective type of test item illustrated above in connection with "Application of Principles" can also be used effectively.

Whether the student *does* apply the generalizations of the science curriculum in his everyday life cannot be determined by the ordinary paper and pencil tests, but may perhaps be discovered by methods that describe his behavior in "real situations." Some teachers detect the actual application of important understandings by placing students in a problem situation and observing their attempts to solve the problem. A teacher may also record anecdotes of the behavior of students in situations that arise accidentally or that are purposely created in the classroom or laboratory or elsewhere, or he may also use interviews, student diaries, and check lists to secure additional evidence.

The anecdote which follows shows significant differences in the application of science generalizations by two students.

In a social-science class discussing the problem of conservation of natural resources, student A made the statement that it was not really such a great problem, because the chemists could readily produce a substitute for any natural product. Student B challenged the statement and cited several examples of the limitations of science at present and showed the harmful effects of waste of certain resources.

CONCLUSION

In conclusion, the purposes of an evaluation program of the type discussed may be summarized as follows: It should help the student, his parents, and his teachers, to discover his needs, to appraise his achievements, and to guide his progress; and it should help the teacher to:

1. Prescribe remedial procedures to correct specific weaknesses on the part of the class or of an individual
2. Compare the efficiency of various teaching procedures
3. Compare the effectiveness of various kinds of subject-matter

In the early part of this chapter, mention was made of the necessity for going beyond the mere giving of tests in a program of evaluation. Tests should be given and their results studied by teachers in order to get as clear a picture as possible of the student; test records from all parts of the school should be brought together, studied completely, and synthesized into a unified picture.

Though it is impossible at this point to give a complete outline of the procedures involved in such a process, a brief account of such an attempt may be of interest. For a certain school, results from the following tests given to students were studied to see if a comprehensive picture of a student could be obtained:

Applications of Beliefs to Social Problems (See tests from this chapter on "Application of Principles" for types of test items used, situations being taken from social areas.) [32]
Interpretation of Data, in the field of social studies [32]
Interpretation of Data, in the field of science [32]
Appreciation of Reading [32]
Appreciation of a Particular Novel [32]

[32] These tests were prepared by the Evaluation Staff of the Progressive Education Association, Commission on the Relation of School and College.

Attitudes toward (*a*) business, (*b*) family relations, (*c*) politics, (*d*) religion [32]
Appreciation of Principles of Logic [32]
Nature of Proof [32]
Interest Questionnaire [33]
American Council on Education Psychological Examination [34]
Iowa Silent Reading Test [35]
Various Information Tests [35]

After studying the results of these tests, word pictures of individual students were written by a person not acquainted intimately with the school and not acquainted personally with the students involved. These particular reports on students were then submitted, without names, to the teachers in the school, who were given only the kind of information contained in the example quoted below. The teachers were asked to read the reports and name the student. Twenty-one correct guesses were made on twenty-five attempts. One of the reports follows:

Student X is a student in the eleventh grade who has spent the major portion of his school experience in the fields of mathematics and science. The score on the American Council Psychological Examination places him at about the 95th percentile and the Iowa Silent Reading Test at the 75th percentile.

In the interpretation of data in science he stands at the top of his class of twenty students in getting the meanings from the data, judging 68 per cent of the interpretations accurately. He is more careful than the other students of his group, is less gullible, and does not go beyond the data to an appreciable extent. He makes very few crude errors in judgment, such as marking an interpretation which is true as false. His greatest difficulty is in recognizing interpretations that are probably true or probably false, indicating that he has difficulty in making extrapolations and interpolations. He is sensitive to the limitations of data and recognizes when the available evidence fails to support definite inferences.

[33] Barton Sensenig, author, under the direction of the Evaluation Staff, *ibid.*
[34] American Council on Education, 744 Jackson Place, Washington, D. C.
[35] Iowa Silent Reading Test, World Book Co., Yonkers, N. Y.

X is one of the few students in the entire school whose ability to interpret science data transfers to the field of social studies. Comparison of the test results on the interpretation of data in science with those in social studies shows that what has been said above in the field of science is equally true in the field of social studies. Scores obtained on interpretation of data indicate a high degree of ability with both science and social-studies data. This is unusual in the school where the correlation between the two tests (2.3 and 2.4) is only 0.44.

He has the ability to recognize logical conclusions in situations involving social problems. He stands in about the middle of the group and shows about equal facility in all four of the principles of logic tested. While his judgment seems to be good, he fails badly when it comes to supporting his judgment by applying the correct logical process. This is especially true in cases of indirect argument and in the application of the "If-Then" process. He shows high ability in distinguishing facts from assumptions, rating among the best in his school in recognizing the critical assumptions fundamental to a debatable conclusion. In organizing a proof he was superior to the other students of his class and included in his arguments most of the relevant facts and critical assumptions needed to prove the conclusions and definitely avoided the use of irrelevant facts and assumptions. His arguments were notably free from contradictions.

He appreciates reading and literature in general to a higher degree than do most of his classmates. His pattern of appreciation, however, differs from the group in these respects: He likes to read much more than do his classmates, wishes more time for reading than is available to him; he is less curious about authors, characters, style, etc., is not much interested in showing his appreciation in creative ways such as drawing, sculpturing, writing, and music. He shows little tendency to identify himself with what he reads, seldom transfers into daily life many of the things he reads about, nor does his reading stimulate him to think about everyday problems. In testing for his appreciation of a particular novel, he showed little originality in thinking. Apparently he chose his novel without seriously setting up criteria, as he evidenced no outstanding characteristics in this test that were not evidenced in the general test on the appreciation of literature. He did, however, show

a greater tendency to visualize himself in the rôle of one of the characters and showed a greater tendency to criticize and evaluate the novel than was shown in the general test.

Although he is spending the major portion of his time in the fields of mathematics and science, he shows more appreciation of language than do 90 per cent of his classmates and is excelled in science and engineering interests by over three fourths of his classmates. He has little appreciation of art, almost no interest in social problems. He is much more interested in mental activities than in manipulative activities, more interested in social activities than in solitary or lonely ones. His total picture evidences no dominant interests and the school might well explore his interests by means of interviews as a means of supplementing test findings.

He is more liberal and open-minded in his beliefs concerning politics, race, and religion than most of his companions and less liberal than his classmates in problems of family relations. In the latter field he is much more uncertain and inconsistent than in the other areas in which he shows an extremely consistent point of view.

In this chapter on evaluation many serious omissions are apparent. Except for the analysis of reflective thinking, the description of the desirable characteristics of personality in terms of specific behavior exhibited by students is notably incomplete. The degree to which anecdotal and observational records have been recommended shows that satisfactory short-cut techniques are still lacking as substitutes for these more direct and more time-consuming methods. The Committee has omitted the discussion of how progress in the meeting of a particular need of a boy or girl may be appraised. Several beginnings have been made at taking some such need as that for wise selection and use of goods and services, pointing out what kinds of behavior indicate progress in the meeting of that need for a given individual or group of individuals, and then recording and appraising this behavior. The Committee regrets that it has not been able to produce examples of this sort of procedure, but as indicated early in the chapter, the whole type of evaluation procedure here discussed is rel-

atively new. Perhaps enough of its basic methodology has been presented and exemplified to enable the teacher to proceed on his own from the point where the examples themselves leave him.

Part IV

USING THIS REPORT AS A BASIS FOR PLANNING THE SCIENCE PROGRAM

X

HOW THE TEACHER MAY MAKE USE OF THE REPORT

The present chapter serves as a guide to the report as a whole and undertakes to give suggestions to facilitate its use by teachers.

REËXAMINING AIMS, PURPOSES, AND CRITERIA

In Part I of this report the Committee has presented for consideration a frame of reference for science teaching in a democratic society and a partial analysis of persistent or recurring needs of adolescents. It is hoped that the analysis there given will help the science teacher (or any other teacher) to reëxamine his aims or purposes. The Committee presents the analysis with no sense of finality, but rather sets forth the results of its thinking for the stimulation they may give to other teachers to examine similarly and make what is to them a criticized and satisfying frame of reference.

It is hoped that the teacher will ask himself such questions as: "What am I trying to accomplish through my teaching, other than to see to it that my students can pass a content examination when they have finished with my course?" "How does my teaching actually affect the behavior of my students?" "Are they more sensitive socially, more capable of social cooperation, are they building the other qualities essential to satisfying life in democracy?" "Can they really use the method of the sciences, and will they be likely to apply at least the spirit of science to the problems of everyday living?" "Is the material which I teach actually valuable to my pupils in meeting their needs and furthering their interests?"

In other words, the science teacher might take the criteria proposed at the close of Chapter II as a point of departure in rethinking this program, asking himself these questions:

Does the work help the adolescent to meet his personal-social needs in the four categories proposed by the Committee?
Does it tend to further the realization of the ideals of a democratic society?
Does it help the adolescent to develop the characteristics of personality essential to effective living in a democratic society?

The meeting of the needs of the adolescent is but one aspect of the threefold criterion proposed. Not only should needs be met, but they should be met in such ways as to contribute to the progressive reconstruction and refinement of the democratic way of life. This makes the problem of selecting learning experiences much more difficult than would be the case were not the science teacher committed to the general purpose of education in a democracy; it necessarily moves into second range of significance the criterion most science teachers have been accustomed to put first—the importance of the science subject-matter. From the point of view of democracy the first question must be: "How shall needs be met in ways to develop persons adequate to the democratic way of life?"

The teacher may reject utterly the criteria set forth by the Committee, or he may find certain of them useful. In either event, out of a careful study of the proposals and of his own program, he should be helped to formulate his own criteria. A group of science teachers interested in curriculum reorganization might use the report in a similar way. In brief, the report might well be regarded as a point of departure for the rethinking of the program.[1]

[1] For the science teacher who wishes to go more thoroughly into the problem of a social philosophy based upon our democratic tradition, the following list of references should prove helpful:

"Issues of Secondary Education," *Bulletin* of the Department of Secondary School Principals of the National Education Association, Vol. 20, January, 1936.

MEETING STUDENTS' NEEDS

Discovering the Needs of Students

The whole problem of needs is an extremely "knotty" one and is being attacked simultaneously by several groups, including the Study of Adolescents of the Commission on Secondary School Curriculum. It is almost certain that the studies now under way will result in vast changes in the school program. Admittedly the Committee operated to a considerable extent upon its "hunches," together with what could be gleaned from the findings of studies now in progress. The result is at best a starting point for the thinking of science teachers and others interested in curriculum reorganization.

It may be argued that these needs, as described in Chapters

"Functions of Secondary Education," *Bulletin* of the Department of Secondary School Principals of the National Education Association, Vol. 21, January, 1937.

The Unique Function of Education in American Democracy (Washington, The Educational Policies Commission and the Department of Superintendence of the National Education Association, 1937).

Boyd H. Bode, *Modern Educational Theories* (New York, The Macmillan Co., 1927).

———, *Democracy as a Way of Life* (New York, The Macmillan Co., 1937).

George S. Counts, *Dare the School Build a New Social Order?* Pamphlet 11 (New York, John Day Co., 1932).

Edmund E. Day, "Basic Responsibilities of General Education in America," *Educational Record,* Vol. 17, Supplement No. 10, October, 1936, pp. 8–22.

Samuel Everett, and others, *A Challenge to Secondary Education* (New York, D. Appleton-Century Co., 1935).

William Heard Kilpatrick, *Education and the Social Crisis* (New York, Horace Liveright, 1932).

———, and others, *The Educational Frontier* (New York, D. Appleton-Century Co., 1933).

———, and others, *The Teacher and Society, First Yearbook* of the John Dewey Society (New York, D. Appleton-Century Co., 1937).

Harold Laski, "A New Education for a New America," *New Republic,* Vol. 87, July 29, 1936, pp. 342–345.

Jesse H. Newlon, *Educational Administration as Social Policy,* Report of the Commission on the Social Studies, American Historical Association, Part 8 (New York, Charles Scribner's Sons, 1934).

Hilda Taba, "Social Sensitivity," Progressive Education Association, Evaluation in the Eight Year Study, *Bulletin* No. 6, University of Chicago, December, 1936 (originally published at The Ohio State University).

Ralph W. Tyler, *Constructing Achievement Tests* (Columbus, Ohio, The Ohio State University, 1934).

III–VI, are so general in character that they do not serve very effectively as criteria for selection, inclusion, and exclusion of specific science content materials. It might be held, also, that reference to adolescents' needs as a criterion excludes too much of the usual thorough and systematic knowledge of pure science, and that such systematic knowledge is essential as background if the adolescent is to participate effectively in economic life. Honest and capable science teachers will disagree on this point. It is true that if the Committee point of view prevails, much conventional material will have to be eliminated from the program, for it has most generally been included to meet the demands of logical organization of subject-matter rather than for its value in meeting the needs of students.

These chapters purposely deal with needs in rather broad categories, in order to avoid the necessity of listing and discussing the multitudinous specific needs that characterize the adolescent in the contemporary culture. Those which have been selected for treatment here could easily have been broken down into constituent items of far greater specificity, but in a final analysis the character of the treatment of needs in any given science program must be determined by the local situation. A group of adolescents in a particular community may well exhibit many needs not common to young people in other communities.

The Committee holds that the particular needs of the adolescent in any given community will vary and that they can only be discovered by a careful study of the group of adolescents for which a given program is being developed. In other words, the teacher should ask: "What are the needs of the adolescent in *X* community?" "And what is revealed as one looks at the adolescent in his personal living, in his relationship to the social-civic and economic life of *X* community in particular?" How can the teacher find the answers to these questions? And once these answers have been determined, for

how long a period of time will they be of value in a rapidly changing culture? Clearly there is no magic to be invoked. It is a problem rather of utilizing available resources and agencies. The following possibilities suggest leads:

1. A study of the individual students in order to discover and define their persistent problems, interests, and needs [2] (The Committee's classification may be found helpful as a basis for such study, or any other more suitable approach may be used.)
2. A study of the community through a survey of occupational, recreational, civic, religious, and community factors with which the growing adolescent is interacting
3. A study of the findings of other groups working on similar problems (for example, the Committee on the Function of Science in General Education and also the Study of Adolescents, of the Commission on Secondary School Curriculum of the Progressive Education Association; the American Youth Commission of the American Council on Education; [3] and the University of California Studies)

Out of such studies, any teacher or curriculum-making group can learn much about the needs of students, even though such information must be regarded as tentative and subject to change with experience.

Having made such a survey in his own particular situation, the science teacher may now wish to use again some of the Committee's proposals as a basis for reëxamining his own program. He may ask himself, for example, what he is doing to help the student meet his need for "a satisfactory world picture and a workable philosophy of life." To see some of the elements involved in accomplishing this, he may turn to Chap-

[2] The assistance of students, parents, and teachers should be utilized, though the data gathered must be carefully interpreted.

[3] Harl R. Douglass, *Secondary Education for Youth in Modern America* (Washington, D. C., American Council on Education, 1937); Homer P. Rainey and others, *How Fare American Youth?* (New York, D. Appleton-Century Co., 1937). Report to the American Youth Commission of the American Council on Education.

ter III of the report where several important aspects of the problem are discussed. The scientific ideas of importance to the adolescent's world picture are there set forth in terms of scientific methods as bases of belief, evolution, scientific laws (prediction and control), efficiency, probability and statistics, and operational thinking.

Most science teachers, of course, deal to some extent with these concepts, but it is important to ask for what purpose they are dealt with, what outcomes are expected to result? For example, is the study of evolution carried far enough actually to affect the beliefs and outlook of the student? Many science teachers present meticulously the *facts* of evolution among lower animals, leaving very vague the problem of man in relation to nature (and most modern textbooks encourage this practice). The student completes his study without ever seeing that this way of thinking about man and his origins is in sharp conflict with other types of explanation. Because of the teacher's insensitivity to the need for helping the student achieve a workable philosophy of life, the student fails to undergo any basic reconstruction of experience—in other words, he fails to be educated at that point.

Suggestions for dealing with this problem are included in the section of the report referred to above, together with lists of generalizations representing some understandings which may reasonably be expected to result if the student actually uses the concept of evolution to reinterpret and reconstruct his philosophy. For the teacher who needs aid in clarifying his own world picture, the bibliography at the end of Chapter III should be of help. Indeed some of the advanced students may also read with profit many of the references cited.

The above is but one illustration of how the science teacher may use Chapters III–VI dealing with the needs of adolescents and suggestions for meeting them. Similar illustrations might be given of the use of material dealing with the other needs.

Using Generalizations and Inquiries in Building the Science Program

Now as to the method of developing generalizations and inquiries in organizing the science program: The curriculum-maker will find many differing precedents to choose from. Once the values or objectives to be sought have been established, he may attempt to list all of the specific facts, principles, etc., pertinent to the ends set up, and then classify and organize this material as subject-matter-to-be-learned. A simple illustration of this procedure is afforded by the average textbook, which provides a definite and concrete pattern to be followed. The Committee believes such a procedure disregards the findings of psychology and is not the best way to secure understandings. The science teacher must himself play a more significant rôle in curriculum-making if his pupils are to get the most out of their science experiences and if he himself is to grow professionally.

Another avenue open to the curriculum-maker is to develop his materials in terms of major problems or questions in the field of science. This approach has much to commend it. The Committee emphasizes, however, that there is no guarantee that a problem of importance in the field of science will constitute a problem of genuine concern to the student-learner, and in so far as it does not, the real psychological soundness of the problem approach is sacrificed. Understandings will be most fruitfully developed by students when, as has been pointed out, they are built in response to needs, problems, inquiries of the student himself. There is no reason why major problems in science should not also be student problems, but, conversely, it cannot be assumed that they will be; the mere statement of a piece of information in interrogative form does not make it a student problem.

The Committee has adopted the relatively simple method of formulating the most important generalizations in the field

as material suggestive to the science teacher in planning his program. Keeping in mind these large "wholes" and keeping in the focus of attention the student needs they are expected to meet, it is possible to deal by implication with a vast amount of material in relatively small compass and without losing sight of the forest because of the trees. In other words, this procedure avoids both the minutiae and the danger of fixity inherent in the first procedure suggested above; it also helps to avoid the danger of setting up a large body of abstract material-to-be-learned; and the process of meeting needs inherently calls for understanding and at the same time involves skills, habits, attitudes, characteristics of personality, all in proper perspective.

It should be clearly understood that the *way in which learning experiences are organized* is of great importance in achieving the characteristics of behavior necessary for the full realization of educational values. The science teacher must keep in mind not only the potential science understandings which may grow out of a given learning experience, but also the need for organizing learning so as to achieve the habits, attitudes, special abilities, and skills important in realizing the educational values of a democratic society. Succeeding chapters suggest types of learning experiences likely to contribute significantly to both understandings and other learning products. But, although specific teaching content will often be mentioned in these chapters, it is important to notice that this content can rarely be separated from teaching methods. A full reading of this report should show that the use of the actual teaching materials suggested will not aid in the attainment of our objectives if they are not set in an educational framework that will give every adolescent at his own level repeated opportunity to think reflectively, to act on the basis of his own tentative judgments, to behave in ways that he realizes are socially sensitive, coöperative, tolerant, and all the rest.

It must be noted that learning activities cannot be "tagged" with certain values, such as "reflective thinking" or "self-

direction" which are their inevitable concomitants or outcomes. To do so assumes an artificial simplicity which has no counterpart in reality. Even if the teacher were to assign some particular value to a learning experience and to teach so as to achieve it, such unwarranted compartmentalization of values would represent a serious distortion of genuinely educational procedure. If learning experiences are rich and meaningful, they inevitably contribute toward the realization of many values. Again, just as different students undoubtedly acquire different "understandings" from a given experience, any given activity has a peculiar significance in meeting each different student's needs and reconstructing his personality. This is but another way of saying that the characteristic modes of behavior are not mechanical elements which exist independently in the individual, but represent rather a synthesis which varies with the previous experience and present personality patterns.

Suggestions for Developing Further Generalizations

The Committee has stated definitely that it holds no brief for its own proposals in Part II. Teachers are urged to criticize the Committee's offerings and to supplement with their own or to substitute their own. To facilitate this process the following guiding principles are presented as having proved helpful:

1. Whenever possible, generalizations and inquiries should be stated as working ideas used by the student in determining his behavior.
2. Generalizations and inquiries should be *interpretative* rather than pure science generalizations in the main. Interpretative generalizations apply the results of science to the elucidation of problems of wide and rather common human concern, whereas pure science understandings apply the results of science to the further development of science itself.
3. Each generalization or inquiry should be stated clearly and concisely, so as to convey a "whole idea" to the teacher who is en-

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gaged in developing suitable learning activities. In general, the statement should be complete in a single sentence.

4. The level of generality upon which the generalization is formulated will depend upon the use to be made of it in teaching and learning situations. The most comprehensive generalizations would be the result of the reconstruction of experience over a period of years. Such statements may have subordinated to them less comprehensive ones which indicate content more specifically. Examples of varying degrees of generality and comprehensiveness are to be found in connection with succeeding chapters.

5. The generalizations should be so formulated as to avoid indoctrination or finality in interpretation.

6. Generalizations should be scrutinized carefully to see whether they do actually have promise of meeting real student needs, or whether they tend to represent adult interest in subject-matter only.

Obviously all of the material which is valuable in any method of curriculum construction can be utilized in formulating lists of generalizations and inquiries. The following are some likely sources:

a. Studies of adolescent needs and interests
b. Studies of the community, or of society at large
c. Reports of curriculum committees
d. Current periodicals in the field of science
e. Authoritative books in science and its application to living
f. Textbooks
g. Courses of study
h. Individual judgments of teachers, scientists, students, and laymen

UNDERSTANDING THE STUDENT

It is hoped that Part III of the report may help the science teacher *to achieve a better understanding of his students.* Up to the present time the training of science teachers has been carried on with little attempt to deal with the dynamics of personality and the growth and development of the student

who is to be taught. Thus, the intellectual aspects of behavior have been regarded as separable, rather than as manifestations of interactions among physical, intellectual, emotional, and environmental aspects.

Chapter VIII is designed to help the teacher to understand some of the techniques for arriving at an understanding of the student, as well as to make the teacher sensitive to contributions from the field of mental hygiene. The bibliography should afford suggestions for pertinent reading. The case of Harold Brown, dealing as it does with a boy who apparently had a keen interest in science, should serve as an illustration of the need of the teacher to examine underlying motives of students and to help them to achieve emotional balance and stability. The science teacher may wish to select one or two students in his class for intensive observation and study with a view to becoming more familiar with the techniques involved.

In the past one of the stumbling blocks in the way of improving science teaching has been the almost total lack of evaluation instruments suitable for testing outcomes other than the acquisition of facts and information. Consequently, while the science teacher paid lip service to such values as scientific method, creativeness, coöperativeness, social sensitivity, and the like, he tested for facts and information. It has been rather well established that the nature of the testing program determines to a very large extent the objectives which actually function as guides for the teacher and the students.

Though only a beginning has been made in developing instruments suitable for testing the values important for living in a democratic society, still the science teacher can use certain instruments with some degree of confidence. Chapter IX seeks to marshal the major contributions in this field and gives suggestions for observing and recording changes in behavior in all of the "characteristics of personality" discussed in Chapter II.

For example, suppose that the science teacher is committed

to the organization of his material for promotion of reflective thinking. What help can he get from the report in evaluating the success of his procedures? A section of Chapter IX is devoted to a discussion of this problem. The process of reflective thinking is analyzed, and suggestions are made for evaluating growth in its various aspects. Citations are given to some of the most important studies in the field, so that the science teacher who wishes to improve his program of teaching may readily determine important recent developments.

REORGANIZING COURSES

A survey of trends in science teaching reveals that significant reorganization is taking place as science teachers seek to adapt their courses to the changing secondary-school population and the complex demands of society. This reorganization appears to be centered in three types of courses, all of which may conceivably exist in the same school. First, there is the *Special Field* course in physics, chemistry, or biology, designed to exploit one of the natural sciences for the purpose of general education; second, there is the *Broad Field* course which draws material from two or more of the natural sciences; and third, the *Unified Core Studies,* or *Integrating* course, organized about topics or problems of general student interest and concern, which draws material from any subject field that can serve its purposes.

Undoubtedly all three types of courses are useful in a program of general education. The types of courses offered in a given school should be determined by the needs of students in the community rather than by some stereotype. The concern of the Committee is to help improve all types of courses, and not to urge the adoption of any particular one.

Special Field Courses

In the past, these courses, particularly in physics and chemistry, have been so organized as to exemplify logical unity,

internal consistency, and the maximum possibility of deduction. For many students these courses have not dealt with problems or issues of practical interest, and they have not been taught so as to help students grow in their powers of reflective thinking. But the special field course may be taught so as to make a valuable contribution to general education.

This happens more readily if the teacher's conventional procedure of assigning a specified number of pages each day in the textbook is abandoned in favor of "unit" assignments. The unit may consist of study of a topic of interest and importance, such as petroleum or cosmetics; it may be the study of a problem with which students are concerned, such as "How do the endocrine glands affect growth?" or "What is the world made of?" Work on the unit continues for several weeks, with students organizing their attack, proceeding to gather material dealing with various phases of the topic, preparing their material for reports, and applying the generalizations they have made.[4]

[4] For the teacher who wishes to examine more fully the various proposals for some type of unit organization the following references are suggested:

Alice E. Carey, Paul R. Hanna, and J. L. Meriam, *Catalogue: Units of Work, Activities, Projects, etc., to 1932*. (New York, Teachers College, Columbia University, 1932).

Roy O. Billett, "Provision for Individual Differences, Marking and Promotion," *Bulletin* No. 17 of the United States Office of Education, 1932, National Survey of Secondary Education, Monograph No. 13, Part II, pp. 227–392.

V. T. Thayer, *The Passing of the Recitation* (Boston, D. C. Heath and Co., 1928), pp. 276–327.

A. Gordon Melvin, *The Technique of Progressive Teaching* (New York, John Day Co., 1932).

William Heard Kilpatrick, *Remaking the Curriculum* (New York, Newson and Co., 1936).

Hollis L. Caswell and Doak S. Campbell, *Curriculum Development* (New York, American Book Co., 1935), pp. 400–447.

Edgar Marion Draper, *Principles and Techniques of Curriculum Making* (New York, D. Appleton-Century Co., 1936), pp. 293–383.

Harry Lloyd Miller, *Creative Learning and Teaching* (New York, Charles Scribner's Sons, 1927), Chs. I and II.

Goodwin Watson, "A Program for American Youth," in Samuel Everett, and others, *A Challenge to Secondary Education* (New York, D. Appleton-Century Co., 1935), pp. 151–174.

Henry C. Morrison, *The Practice of Teaching in the Secondary School,* Rev. ed. (Chicago, University of Chicago Press, 1931).

Teachers of special field courses may find help in this report in determining suitable objectives, selecting appropriate generalizations, and evaluating the results of instruction. An example of a special field course in chemistry, worked out by Maurice Ahrens, Norris Bush, and Ray Easley in the Denver schools and organized so as to serve the purposes of general education, is given in the appendix.

Broad Field Courses

In another type of course the broad field of the natural sciences is drawn upon for subject-matter according to some principle of selection. The subject-matter may be selected so as to give a student an overview of the sciences (their factual content, their fundamental principles, or both), or the subject-matter may be selected so as to help the student develop some of the major understandings discussed in this report, or the subject-matter may be selected so as to help the student answer certain pressing questions, such as: "How may I keep in good health?" "Do my religious views conflict with the teachings of science?" "What things are inherited?" "What should we do about our natural resources?" Finally, some of the personal-social needs of young people furnish suggestions for subject-matter. For example, the need for a world picture indicates that a course might be devoted to the study of evolution, cosmology, energy, determinism, and other subjects that would help students to understand the scientific world picture.

The statement of objectives of general education given in Chapter II should be useful to the teacher who is organizing a broad field course in the natural sciences, as should the description of student needs and suggestions of ways by which the science teacher may help his students meet these needs (in Chapters III–VI). The lists of generalizations given in these chapters may help the teacher in selecting the content for his course. An outline of a course in physical science given by Asa C. Tenney at Tower Hill School, Wilmington, Delaware, is included in this report as an illustration of a broad

field course. A unit on public health is also included, which is part of a broad field course taught by H. G. McMullen at the University of Wisconsin High School, Madison, Wisconsin.

Unified Core Studies Courses

Whenever a group of teachers studies the problem of organizing the program of a school so as to help students meet their needs, a suggestion is always made to the effect that a part of the school day should be given to a course that draws its material from all of the subject-matter fields represented in the curriculum. Such student needs as those discussed in this report cannot be fully met by work in any one subject field. The teacher of social sciences, or of mathematics, or of English, could discover potential contributions from his own area to the meeting of these needs, just as has been done here for the natural sciences. Whereas each department of a school might conduct special field and broad field courses designed to contribute its share to helping students meet their needs, an alternative procedure would consist in teachers from several subject areas joining together to develop a course that called upon the resources of their special fields.

This procedure is the basis for an increasing number of so-called core programs being developed in some secondary schools, where a large block of the student's time is given over to a single unified course based upon "The Progress of Man Through the Ages," "Problems of Social Living," "Life Activities," "A Study of Cultures," or similar broad themes. Such courses are usually required of all students, but are sufficiently flexible in organization to facilitate the satisfaction of special interests and needs within the general framework of the course.

Schools have experienced two very important problems in connection with this type of course. The first one concerns the source of unity. How shall logical organization be secured? In some schools this problem has been solved by making historical sequence, or chronological development, the thread

which binds the various contributions together and secures continuity of treatment. In some schools this procedure leads to dissatisfaction among teachers of the various fields because of a fear that their subjects are being "swallowed up" by the social studies. The other problem concerns the administration of the course. Schedules are rarely flexible enough to make it possible to utilize teachers at appropriate times as the study shifts from one aspect of a given problem to another. The result frequently is that the course is handled largely by the social-studies teacher, and the bringing in of teachers of other fields becomes somewhat casual and incidental.

The first problem is being met in some schools by refusing to consider any one subject as the source of unity, but rather by basing the "core" upon the needs or problems of adolescents. Logical arrangement is secured by considering the persistent or recurring problems on successive levels, the teachers being careful to help the student to build the kind of organization best suited to his own evolving purposes. If and when the student develops specialized interests which tend to fall more directly in logically organized fields, he is encouraged to pursue such studies, in broad field courses such as "Science and Civilization," "Man and Nature," "Science and Human Living," or in the more specialized fields, such as biology, physics, or chemistry. The second problem, concerning administration, is being solved by the greater flexibility of programming possible in the more informal type of laboratory teaching that is being utilized increasingly as the conventional daily recitation method passes out.

It is not the purpose of the present discussion to endorse the "core type" of program, or any other program for that matter, since the Committee holds that procedures should be adapted to the particular situation in which they are to be used, and a type of program which may prove highly successful in one situation may be a failure in another. The important point is that procedures should be kept flexible and experimental in character, always with a careful appraisal of

results with reference to the purposes to which the school is committed.

However, it should be pointed out that this report, dealing as it does with the needs of the adolescent in the basic aspects of living, offers much help to schools that wish to develop a core type of curriculum—and this help is not necessarily restricted to the area of science. The purposes set forth are intended to be applicable to the entire program of the school, and the technique of building the program upon the needs of adolescents in the basic aspects of living is equally applicable to all areas. Though there may be some doubt as to the desirability of extensive use of the "understandings" technique—as it has been exemplified here—in all areas, it is undoubtedly at least suggestive for work in other areas. That it is becoming more popular is evidenced by its use in the social studies, industrial arts, and home economics. In like manner the techniques of evaluation proposed in Chapter IX may be generalized sufficiently to make them effective in fields other than science, since they are based upon the purposes of general education rather than upon specific purposes related only to science teaching.

BUILDING SOURCE UNITS

Some schools in attempting a reorganization of program are finding it desirable to construct source units which are intended to give aid to the teacher in becoming oriented in unfamiliar fields and in the coöperative planning of learning experiences. This is particularly necessary in situations (1) where a number of teachers in various areas work together in planning a program which unifies a number of hitherto relatively unrelated fields, or (2) where the material is scattered and consequently difficult to secure. Such units are not intended to serve directly as guides to the organization of classroom teaching, but rather as resources upon which the teacher, planning with his pupils, may draw in providing for suitable learning experiences.

The specifications of source units will vary with the particular situation, and hence it is undesirable to set up a rigid pattern for their development. The following suggestions may, however, be useful:

1. Define the student need or needs to be met.
2. Set forth the principal values, or characteristics which the teacher should keep in mind in planning experiences designed to meet the needs.
3. State the problems, issues, and basic concepts or generalizations involved.
4. Suggest a large number of possible individual and group activities which might prove to be helpful.
5. Provide suitable annotated reference materials for students.
6. Suggest appropriate equipment, visual aids, and the like.
7. Provide suitable reference and other material for the use of the teacher.
8. Suggest a wide variety of procedures which the teacher might use in planning and developing the unit.
9. Suggest possible learning outcomes in the form of major understandings, special abilities, and the like which may reasonably be expected to result from the learning experiences of students.
10. Offer suggestions as to how achievement of these proposed outcomes may be evaluated.
11. Suggest "leads" to other related units which might grow out of the proposed unit.

This report should be of assistance to a curriculum-making group confronted with the problem of building source units. For example, many schools are constructing units dealing with consumer education. Frequently these units draw upon fields other than science, as well as the various aspects of science such as biology, physics, or chemistry. In Chapter VI there is a discussion of "the need for wise selection and use of goods and services." A number of suggested learning activities and a selected bibliography are provided. Chapter VII, which contains an analysis of reflective thinking, should be of value in constructing source units of all types. The various aspects of

physical and mental health are treated in Chapters III and IV in such a way as to provide suggestive materials for source units dealing with the health problems of students. These are but illustrations of the way the report may prove to be helpful. A course unit on genetics, together with a discussion of the technique of developing source units, by Gertrude Wylie Diederich, is included in the appendix.

Appendices

ILLUSTRATIVE MATERIAL

This section of the report is concerned with the task of providing concrete examples of learning experiences selected and organized in accordance with the principles stated in this report. Since the Committee has tried to formulate a useful theory of science teaching growing more out of what it believes can and should be done than out of what it sees actually being done, even the best practices that it can discover will fall short in some respects of the goals that have been described. Yet it seems better to illustrate the report with examples of actual practices than with paper plans that have not stood the tests of experience in actual teaching.

The desirability of putting into this report some accounts of good teaching that illustrate more or less fully the principles of the report seems to outweigh the dangers that such illustrations cause—the danger that readers will merely imitate these examples, and the danger that readers will think of the few illustrations as representing the only ways that science should be taught so as to bear out the principles here presented.

I. A COURSE IN FUNCTIONAL CHEMISTRY

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East High School, Denver, Colorado

Introductory note by the Committee. We have asked the permission of Messrs. Ahrens, Bush, and Easley to include in this report a description of their chemistry course because this course seems to us to possess many valuable suggestions for the teacher who, for one reason or another, elects to teach a course in chemistry rather than one in the broad field of physical science or one that is organized around problems or needs of students in such a way as to require materials from several subject areas. The Committee believes that this course exemplifies a useful and suggestive adaptation of the materials of chemistry to the purposes of general education. It is based on the same analysis of the activities or aspects of living as is this report; that is, the Chemistry of the Individual, of the Home, and of the Community and Nation in the course parallels the aspects of Personal Living, Immediate Personal-Social Relationships, Social-Civic and Economic Relationships of the report. The methods employed in conducting the course—the use of committees, individual or small group projects and reports, student leadership—are such as to encourage the development of coöperativeness, intelligent self-direction, self-assurance, wider personal interests, and reflective thinking. The emphasis upon the social consequences of chemistry is such as to encourage the development of social sensitivity and understanding of social-civic and economic relationships. And the study of the chemistry of the individ-

ual and of the home helps the student to meet his needs for physical health, self-knowledge, vocational choice, and skill in the operation of a household.

For a number of years we have recognized two important limitations in chemistry courses as they are usually taught: (1) the failure of chemistry to contribute to the needs of the individual student, and (2) the isolation of chemistry from the scheme of general education. With these limitations in mind a reorganization of the course of study in chemistry was begun four years ago. After this course was well under way, we came in contact with the work of the Committee on the Function of Science in General Education, of the Commission on Secondary School Curriculum, Progressive Education Association, and discovered that our work was somewhat in accord with the views of that Committee. Our course has profited to some extent from our contact with that Committee, but it is not to be taken as an illustration of the Committee's recommendations.

Objectives of the Course

One of our first problems was that of discovering just what students could expect to get from a course in chemistry that would be valuable to them as a part of their general education. At the beginning of the experiment it was impossible to say with any exactness what such objectives should be. Over a period of several years students were asked what they thought chemistry might contribute that would be helpful to them. Their answers were tabulated, and those that occurred with some frequency were used in the organization of the course. Each new class considered the list of objectives that previous classes had formulated, and was asked to reject, modify, or add to the list. The objectives upon which there has been general agreement are:

1. The study of chemistry should help me [the student] to form the *habit of thinking scientifically.*

This objective was so all inclusive that it was found necessary to discover the characteristics of scientific thinking. These characteristics probably include:

a. The *suspension of judgment* until all available significant facts have been ascertained and analyzed

b. Learning to distinguish between *prejudiced* and *unprejudiced opinions*
c. Demanding adequate evidence before settled conclusions are reached
d. Relying on the tested results of reputable workers
e. Insisting upon *accuracy*
f. Being *curious* and *observant*
g. Being *tolerant* and *broad-minded*
h. Being *ready to act on the basis of tentative judgments*
i. Realizing that behind every *result* there is an adequate *cause*
j. Using the *scientific method* of solving problems

2. The study of chemistry should help me to develop the ability to study and investigate intelligently any individual problem which may be of interest to me.

3. The study of chemistry should aid me in discovering and developing new wholesome leisure-time activities.

4. This course should help me to gain some knowledge of health and to acquire proper habits of health.

5. This course should help me to develop understandings which will make it possible for me to select and use goods and services wisely.

6. This course should provide for me an opportunity to explore vocations closely connected with science so that I may plan for the future more intelligently.

7. This study should help me to understand, at least partially, the significant changes that have been brought about by science in my own life and in society in general.

8. This course should help me to develop an understanding of the relationship of industry to society.

Planning and Organizing the Course

The work of the year is organized in the following units:

I. Why Study Chemistry
II. Importance of Chemistry in Modern Life
III. The Fundamentals of Chemistry
IV. Chemistry of the Individual
V. Chemistry of the Home
VI. Chemistry of the Community and Nation

The first three units are introductory to the last three, which we call "functional units." To the first three units we devote a maximum of twelve weeks, or less than one-third of the whole course.

Following Unit I, in which we consider the objectives of the course, we present a short unit, the purpose of which is to stimulate interest in the sciences by pointing out their impact upon the student's life and upon society in general. In a preliminary discus-

sion, the students who appear to be especially interested in the unit are asked to work out reports for the class on such questions as:

1. What effect has the development of medicine upon the lives of people?
2. How have chemical industries changed society?
3. What is the importance of chemistry in modern civilization?

Teaching the Fundamentals

Our next step is to teach such fundamental facts and principles of chemistry as will be needed in the later parts of the course. Although we considered the possibility of beginning immediately with the main part of the course, dealing with the individual, the home, and the community and nation, and working in the basic facts as they were needed, we finally decided to teach at the beginning the basic technical chemistry which would probably appear in the main part of the course. Our reason for this decision was that we thought the effectiveness of the main part of the course (the functional units) would be spoiled if we had to stop often in such a unit to teach the technical facts and operations of chemistry.

After conducting the course for two years we checked back from the functional units of the main part of the course to discover the fundamental or basic chemistry that was actually needed. These fundamentals are as follows:

Matter
Energy
Structure of Matter
Formulas
Oxygen and Hydrogen (very brief)
Solutions and Ionization
Equations
Acids, Bases, and Salts

Since only about ten weeks are devoted to this unit, the study of these topics is necessarily confined to a minimum of what is needed for the functional units.

The Functional Units

In the selection and organization of content for a course in functional chemistry we believe it is essential to use some such criteria as the following:

1. How does it help the student to meet his needs?
2. How does it help the student to do the things that we suggested in our statement of objectives? That is, how does it help him to:
   a. Think scientifically
   b. Develop the ability to study problems individually
   c. Develop wholesome leisure-time interests
   d. Gain knowledge and attain proper habits of health
   e. Select and use goods and services wisely
   f. Plan his vocational future intelligently
   g. Understand the consequences of science in individual and social life
   h. Understand the social consequences of industry and technology

What would be the best way to begin such selection and organization of content? At first we thought it would be feasible to have students list some of their needs which they thought could be met through a study of chemistry. Of these needs, those appearing most frequently could constitute a basis for study. From each problem selected on such a basis other problems would arise as the study progressed. To illustrate, let us suppose that such a problem is, "How can I select and use cosmetics wisely?" In the study of this problem there would probably arise new, yet closely related problems. Some student is certain to ask how pimples can be prevented or how they may be removed by the use of certain advertised cosmetics. This would open up a problem requiring the study of diet. But although there was much to recommend this kind of scheme, we felt that it would lead to an unwieldy, haphazard organization.

Our next idea was to classify the needs of students into broad categories. We thought that this procedure would result in a more orderly organization, and yet give wide latitude to student-teacher planning and make it possible to meet students' needs. The following classification was decided upon:

1. What contributions can chemistry make to the individual?
2. What contributions can chemistry make to the home?
3. What contributions can chemistry make to the community and nation?

Each of these categories is used as the basis of a functional unit. The similarity of this classification to that of the basic aspects of living in *Science in General Education* is at once evident.

When we come to the three functional units which are the main

part of the course, we have twenty-six weeks of the school year left for them. Our students by that time have a fair comprehension of the basic facts and principles of chemistry; all of them have studied general science in the junior high school; and many of them have studied biology.

Chemistry of the Individual

Our first step is to present to the class our first category of human activities that have to do with individual or personal living. We ask them to consider those of their needs which are most individualistic and with which the study of chemistry might help them. Some will say that they need an understanding of glands, others of digestion or diet, others of cosmetics, etc. The list always continues to great length.

When we have a large number of such questions or problems, we call a student committee into conference to organize these problems and to simplify and restate them whenever it is desirable. The list is then mimeographed and placed in the hands of each student. The student is asked to check those problems which he believes concern him personally. A tabulation is then made of the checked problems, and those which apply to the majority of the class are selected for study.

The following outline illustrates the most common problems which are suggested by students in the first category, that of individual living.

I. *Chemistry of Water in the Body*

- *a.* How much of the various parts of the body is composed of water?
- *b.* What are the sources of water for the body?
- *c.* What importance do water and water solutions have in digestion, assimilation, circulation of the blood, excretion of waste materials, and temperature control?
- *d.* How much water should a person drink?
- *e.* Of what value are advertised mineral waters?
- *f.* Are mineral spring resorts valuable health agencies?

II. *The Chemistry of Food Within the Body*

- *a.* What are the food nutrients?
- *b.* What is the chemical nature of these nutrients?
- *c.* What functions do they have in the body?
- *d.* What are the richest food sources of each nutrient?

e. How are these nutrients acted upon in the digestive process?
f. What happens if the body does not receive a sufficient amount of any one nutrient?
g. Of what value are particular diets for gaining or losing weight?
h. How much reliance can be placed upon the advertisements of foods which claim special nutrient values?
i. What are the reliable sources of information about foods and diets?
j. How may foods be adulterated?
k. What are the disadvantages of adulterated foods?
l. What are the most common methods of preserving foods?
m. What are the advantages and disadvantages of food preservation?
n. Where can one get the most reliable information about the choosing and eating of food?

III. *The Interdependence of Plant and Animal Life*

a. How do plants produce food?
b. How do animals produce food?
c. What interrelationship exists between plant and animal life?

IV. *The Chemistry of Glands of Internal Secretion*

a. What are the endocrine glands?
b. What are the functions of the hormones secreted by each of these glands?
c. What happens when one or more of these glands do not function properly?
d. How much control does medical science have over the various glands?
e. Is rejuvenation through gland transplantation successful?
f. What are some advertised products which rely upon gland quackery?

V. *The Chemistry of Bacteria and Disease*

a. How does chemistry explain natural and acquired immunization?
b. How are serums, anti-toxins, and vaccines made?
c. How do they act in the body?
d. What are the relative values of various methods of causing immunization?

VI. *The Chemistry of Drugs and Medicines*

a. Antiseptics
1. What are the most commonly used oral and surgical disinfectants and antiseptics composed of?

2. How powerful is each one in killing or restraining growth of germs in the body?
3. How are germs killed?
4. What surgical disinfectant is the most reliable?
5. What oral antiseptic is the best to use?
6. What dangers may accompany the use of antiseptics and disinfectants?

b. Self-administered Medicines

1. Laxatives
   (*a*) What is the chemical composition of the most commonly used laxatives?
   (*b*) What causes constipation?
   (*c*) How do the various laxatives act to relieve constipation?
   (*d*) What dangers are involved in the use of laxatives?
   (*e*) How can constipation be corrected?
   (*f*) What is the best laxative to use?
2. Burn Preparations
   (*a*) What is the chemical nature of the most commonly used burn preparations?
   (*b*) What burn preparations should be used in the home?
   (*c*) How should a burn be treated?
3. Headache Remedies
   (*a*) What is the chemical make-up of the most commonly advertised and used headache remedies?
   (*b*) How do these preparations act to relieve headaches?
   (*c*) What are the values and dangers connected with the use of these remedies?
4. Stimulants and Narcotics

   The following problems are discussed with reference to tea, coffee, alcohol, cocoa, coca cola, tobacco, opium, cocaine, morphine, marijuana, and anesthetics.
   (*a*) What is the chemical composition and nature of each of these substances?
   (*b*) How do they affect the human body?
   (*c*) What values accrue from their use?
   (*d*) What dangers are involved in their use?

VII. *The Chemistry of Clothing*

a. What is the function of clothing?

b. What are the chemical properties, composition and methods of manufacturing of woolen, cotton, silk, rayon, linen, and synthetic goods such as woolstra, vistra, etc.?

c. What simple chemical tests can be made to distinguish various fabrics?

d. What factors must be considered if one is to be an intelligent buyer and consumer of clothing and fabrics?

VIII. *The Chemistry of Cosmetics*

a. What is the composition of the many preparations which are classed as cosmetics?
b. How are these preparations made?
c. What are the actual values of the various cosmetics as compared with their advertised values?
d. How does the cost of materials compare with the selling price of each cosmetic?
e. What improvements in society have resulted from the use of cosmetics?
f. What dangers may result from the use of cosmetics?
g. What are the possibilities of home manufacture?

IX. *Chemical Hobbies*

a. Photography
b. Home laboratories
c. Collection of minerals
d. Crime detection
e. Etching
f. Chemical microscopy
g. Home manufacturing

X. *Vocations Related to Chemistry*

a. Chemical engineering
b. Metallurgy
c. Pharmacy
d. Medicine
e. Nursing
f. Laboratory techniques
g. Dietetics
h. Home economics
i. Teaching
j. Bio-chemistry
k. Dentistry
l. Research
m. Veterinary medicine
n. Government service

It is necessary to keep in mind the fact that this list of problems is not considered completely in each class, nor does each student study all the problems taken up by the class.

After having decided upon the major problems of the unit our next step is to help each student to work on the problem in which he has the greatest interest. Students are urged to form committees

based upon common interests. The committees, and individuals who have not joined committees, are asked to hand in a first, second, and third choice for a problem to work on. From these choices the student-directing committee and the teacher make assignments for research. In a few cases we permit duplication of problems rather than force a student or committee to work upon a problem of no interest.

Each student or committee then begins to work on the problem selected and to prepare a report for the class. In the unit on "The Chemistry of the Individual," we allow one and a half to two weeks for this work. Frequent conferences are held with the teacher. One very important conference is devoted to discussion of the outline to be used in preparing the report. There is another conference on the first draft of the written report. Although the full class and laboratory time is given to this work for two weeks, most students find it necessary to do some of their work outside of class time. Frequently committees will ask members of the class to hand in lists of questions concerning a given problem.

When work begins on the functional units, the class is asked to elect officers to conduct the class for the balance of the school year. The chairman then presides when individuals and committees give their reports. We have found it essential that these reports be given from an outline, and not read from a written paper. The manner of presentation of committee reports is decided upon by each committee, with the provision that each student must report to the class at least once during the year. After the report there is a period of discussion when questions are often asked which the committee cannot answer immediately. In such cases the committee makes a further study and reports again. At the end of each report and discussion a summary is made, based upon what the students say they have learned that is valuable in meeting their needs.

We believe that students should bear some responsibility for digesting the information from the various reports. Therefore, we require a notebook, not highly artistic or typewritten, but one which will serve the student for reference. Many students take a great deal of pride in their notebooks.

In connection with a consideration of vocations and of hobbies there is a variation in procedure. We ask each student to explore

at least two vocations that have to do with chemistry. And we ask each student to try a chemical hobby throughout the school year.

As essential as a laboratory in this course is a library of books and pamphlets which are freely available. We have built up a useful library, at the cost of a great deal of searching for and collecting of pamphlet material, but at no great expense in money.

The Other Functional Units

The procedure in the last two units is broadly similar to that in the unit on the individual. But it is sometimes necessary to arrange for work on Unit V or Unit VI while reports on Unit IV or V are in progress. If work on vocations and hobbies and the taking of notes on reports is not filling the time of most class members, the reports are stopped at a convenient point, and the work of the ensuing unit is organized, so that research outside of class time can be carried on while the reports are being finished. If we find that the class is occupying its time fully during the report period without working on the ensuing unit, we do not introduce that unit until the close of the reports.

The subjects covered in the last two functional units are as follows:

V. *Chemistry of the Home*

- *a.* Chemistry of cooking
- *b.* Chemistry of cooking utensils
- *c.* Chemistry of table ware
- *d.* Chemistry of fuels
- *e.* Chemistry of refrigeration
- *f.* Chemistry of sanitation
- *g.* Medical services in the home
- *h.* Chemistry of construction and construction materials
- *i.* Chemistry of paints, varnishes, and lacquers
- *j.* Chemistry involved in landscaping and gardening

VI. *The Chemistry of the Community and Nation*

- *a.* Chemistry of water purification
- *b.* Chemistry of the manufacture and distribution of foods
- *c.* Chemistry of sewage disposal
- *d.* Chemistry of purification of air
- *e.* Chemistry of industries

Evaluation

Although tests are given during the report period to find out what facts and understandings the students are getting, we have not yet developed a satisfactory evaluation program. We are now working on an evaluation program which may enable us to discover the extent of a student's achievement of several of the objectives agreed upon at the beginning of the course. We contemplate the use of tests on the interpretation of data and on reasoning ability. We hope to work out a health questionnaire for both students and parents, one form to be given at the beginning of the course, another form at the end. We believe that such a course as we are giving needs an evaluation program that measures student achievement of the major objectives.

Conclusion

There are several things about the course that have not been explained adequately. We have barely suggested our attempt to use a democratic organization and procedure. We have probably not shown fully how the course is adapted to the individual needs of students. We have not had the space to show how the social implications of each problem are considered, or how the reports and discussions continually bear on the interests and problems of the consumer of goods and services.

If popularity is a measure of success, this course has been reasonably successful. In one Denver high school, where all the chemistry is taught in this way, the enrolment in chemistry classes has more than doubled in the last four years. As an experimental attempt to meet the needs of boys and girls we believe this course to be in the midst of a long process of development. Even after we have succeeded in rounding out certain hitherto neglected aspects of the course, we shall expect the content to undergo constant revision.

II. A FUSED PHYSICAL-SCIENCE COURSE

GRADE 11

ASA C. TENNEY
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Introductory note by the Committee. The fused physical-science course given by Mr. Tenney is required of all eleventh-grade students. It completes the secondary-school science work of many. For a considerable number of others it furnishes the foundation for twelfth-year science courses consisting of one-half year of physics and one-half year of chemistry. Experience with this type of two-year sequence indicates that it prepares students for college entrance with the same general background in science as would be obtained from one full year's work in physics and another in chemistry. The two-year students therefore receive the prevocational training in science customarily given at the secondary level and those taking one year of science get a broader concept of physical science than would be received in one year of *either* physics or chemistry. This type of organization seems to meet the requirements of both groups of students in a small school where only one section of a course is needed to include all the students in a given grade.

Several features of Mr. Tenney's outline merit special attention. The manner in which *student needs and qualities of personality* have been used as criteria for the selection of both content and teaching techniques is interesting and may prove profitable to other teachers.

The application of *operational thinking* in the formulation of objectives has resulted in a series of clear and functional statements that have definite implications for classroom procedure. The analysis of objectives into operations is followed in each case by a statement of the methods to

be employed by the instructor in aiding students to make progress toward the objective stated.

Space does not permit a detailed description of the entire course. Therefore, Unit I is treated in detail to illustrate the development of a unit, and the subsequent units are outlined briefly in order to show the total year's plan.

The first unit is described as it actually developed in the classroom through student-teacher planning. The instructor had available a comprehensive source unit (similar in nature to the source unit on genetics presented below in this section). The list of *learning materials* covers the material used by the class and is not intended as a comprehensive list of all possible materials, activities, and bibliography.

Techniques Used in Building the Course

The technique used in building this course may be described somewhat as follows:

1. The needs of the adolescents for whom it is intended are studied and set down. Many of these needs are common to every one in our civilization but are particularly vital to young people. Information from psychologists and psychiatrists, such as that contained in *Science in General Education* is useful in locating needs. Other needs can be discovered through the study of the social-economic background of the school in question, and some of the students in the oncoming class will have particular personal needs, about which the teacher can learn only by gaining access to considerable information from teachers and others who have previously come in contact with the individuals who make up the group.

Following is a list of some probable needs of one class which can be partly met in a physical-science course:

1.1 General
- 1.11 Participation in democratic processes
- 1.12 Development of maximum intellectual efficiency
- 1.13 Development of maturity in relationships with adults and age mates of both sexes
- 1.14 Personal health and concern with public health
- 1.15 Self-confidence based on insight, abilities, and constructive attitudes toward self and others
- 1.16. Creative outlet along the line of a major interest
- 1.17 Development of flexibility in adaptation to our changing culture

1.2 Special for class
1.21 Numbers 1.11, 1.12, and 1.17 above
1.22 Broadening of the social horizon (under 1.13). This class needed to become more sensitive to
1.221 Scientists and their work, past and present
1.222 People in the community outside their parents' circle
1.3 Special for individuals
1.31 Special aspects of any of the above needs; for example, the need for greater self-confidence in dealing with subject-matter (from 1.15); the need for locating a major interest (from 1.16); the need for consistency in attitudes toward social problems (from 1.22)
1.32 Development of particular skills in writing, speaking, spelling, or mathematical computation
1.33 A broad background of related facts within the framework of physics and chemistry. (Many students in this class will take up engineering.)

2. Lists are made of those desirable characteristics of personality which can be expected to help adolescents meet their own needs. For the purposes of this course, they may be indicated roughly as follows:
2.1 In personal life
2.11 Skill in reflective or scientific thinking
2.12 Ability to direct one's own activities without much help from others
2.13 A reasonable amount of self-assurance
2.14 Constructive personal attitudes toward oneself and the world
2.2 In social life
2.21 Ability to participate effectively in democratic processes
2.22 Faith in intelligence in solving social problems
2.23 Sensitiveness to other individuals and groups
2.24 Social responsibility
2.25 Constructive attitudes toward social problems

Needs and characteristics of personality, considered together, are criteria for methods of teaching. They serve at the same time to point the objectives for the course, and for its separate units. Teaching methods are discussed in describing the first unit.

3. Course content is found in the things, processes, ideas, and relationships with which young people are already in contact in the home and community and in anything in their total environment which has made an impression on them. Half a dozen convenient centers are worked out for the organization of learning experiences. Beginning with the home, these extend outward through the community to the world, the treatment meanwhile becoming more general as there is more and more solid basis for generalizing. The first two units deal with home machines and household supplies. (Here and elsewhere no attempt is made to exclude related topics. Machines encountered at

school or on summer vacations may be included.) The third unit deals with utilities furnished to the home; the fourth with industries which supply the home with commodities; and the fifth with the earth, which supplies energy and raw materials for industry and whose nature determines life upon it. A sixth unit is added for review and for "filling in" for those who will continue with physics or chemistry (one semester each) in the senior year.

In describing the course itself, general objectives are stated, and the first unit is described in some detail while the others are sketched in very briefly.

Objectives of the Course

If course objectives are to function efficiently as criteria for the selection of method and content, and if they are to serve as guides in the determination of evaluation procedures, it is necessary to state them in terms of student behavior. In other words, the author believes that objectives have little significance unless they are analyzed into operations. What do students do who have achieved or are making progress in achieving the objectives? The following list analyzes the course and unit objectives. In addition, an attempt has been made to list possible classroom procedure which may facilitate the achievement of these objectives by the group.

1. A student who is *skilful in critical thinking*
   - 1.1 Can discover and define problems (is curious, but does not try to solve problems on which there are no data)
   - 1.2 Observes accurately in the laboratory and outside it
   - 1.3 Shows discrimination in selection of data and is reasonable in his interpretation of them
   - 1.4 Formulates fruitful hypotheses
   - 1.5 Reaches justifiable conclusions which do not claim too much or too little from the data
   - 1.6 Is resourceful in attacking problems and flexible enough to criticize a line of action at any point and revise plans of procedure
   - 1.7 Formulates and carries out a plan of action even when it must be based on inconclusive evidence and tentative judgments
   - 1.8 Evaluates authorities, seeing through propaganda and fake advertising

SUGGESTED CLASSROOM PROCEDURE

Planning of a great deal of the work as problems which can be solved only by laboratory work, interviews, and extensive reading (Probably not all the class work should be so set up. Even eleventh-grade students need a rich experi-

ence in science, and problem-solving is a time-consuming process. Besides, requiring a student to track down answers to questions known by the teacher is not true to life, nor does it seem so to an adolescent.)
Frequent use of paper and pencil tests of factors of thinking (Besides measuring progress, these tests become an excellent teaching device. See Chapter IX.)
Criticizing arguments of speakers and writers outside school

2. A student who *has a reasonable amount of self-assurance*
   2.1 Is not touchy
   2.2 Does not disturb the class to gain attention or show off in other ways
   2.3 Shows poise, self-respect, and respect for others

Suggested Classroom Procedure

A constructive attitude on the part of the teacher toward all pupils, with absence of hostility toward any
Insurance of emotional satisfaction to students through guidance into projects which are challenging but not beyond their ability
Seeing that every student gains respect from the class because of his contributions
Helping each student develop a dynamic personal philosophy (See 6 below.)
Acquainting students with adults in the community

3. A student who *is flexible* is able to shift his viewpoint or his method of attack with changing conditions (This requires the development of resourcefulness and open-mindedness.)
   3.1 Customarily considers all points of view
   3.2 Suits his attack to the problem, does not merely use habitual response
   3.3 Accepts reality, including change

Suggested Classroom Procedure

Giving a minimum of directions for procedure in laboratory work
Varying teaching methods from time to time so that new situations can be presented

4. A student who *directs his own activities intelligently*
   4.1 Can be trusted to work even if the teacher is not present
   4.2 Does not ask for help until his own efforts have proved unsuccessful
   4.3 Has purposes of his own which he relates to his work

Suggested Classroom Procedure

Enlisting pupil coöperation in planning and carrying out work
Encouraging flexibility
Keeping to a minimum of set material-to-be-learned
Insisting, sympathetically, but as a matter of course, that students accept the consequences of their own actions (This necessitates freedom to make mistakes.)

5. A student who *has well-developed personal interests,* spends considerable time and effort in pursuit of these interests

Suggested Classroom Procedure

Offering a rich and varied program (A great deal more work has been outlined than any individual is expected to cover.)
Understanding individual students and showing interest in their free choices
Contributing to the student's self-assurance (See 2.1 and 2.3.)
Offering material pointing toward vocations and encouraging study of vocations in which a student evinces interest
Encouraging self-activity through projects chosen by the student himself (See 4.)

6. A student who *has a dynamic personal philosophy*
   - 6.1 Is impatient with inefficiency
   - 6.2 Thinks critically and operationally
   - 6.3 Does not have conflicts and inconsistencies in his thinking and behavior
   - 6.4 Reads and discusses books and articles which contribute to his world picture
   - 6.5 Has come to an understanding with himself on the question of religion
   - 6.6 Is eager for life but is not easily surprised

Suggested Classroom Procedure

Bringing out the social-economic implications of consumption and production; for example, problems of labor, distribution, technology, conservation, the scale of living, working conditions, competition, government regulation, markets, war
Giving consideration to the home, its place in society, the relationships of the members in it
Giving the student the experience of freedom and democratic participation
Adding certain elements to his world picture (determinism, physical evolution, adaptation)

7. A student who *is interested in physical health—personal and public*
   - 7.1 Shows intelligent health habits at home and at school
   - 7.2 Asks about working and housing conditions when on field trips
   - 7.3 Knows the city water supply and sewage-disposal arrangements
   - 7.4 Knows the ordinances governing public health and is concerned about their enforcement

Suggested Classroom Procedure

A study of consumer articles, medicines, sanitation, safety, etc., as indicated under each unit

8. A student who *participates in democratic processes*
   - 8.1 Helps lay out work to be done by the entire class

8.2 Contributes to the solution of group problems and participates in group projects

SUGGESTED CLASSROOM PROCEDURE

Carrying out the greater part of the class work through class and committee organization, the teacher's function being that of adviser and technical expert

9. A student who *has faith in his intelligence in solving social problems*
   - 9.1 Applies intelligence in the solution of social problems in the classroom and in the school
   - 9.2 Is realistic and unbiased on social questions

SUGGESTED CLASSROOM PROCEDURE

(See 8 above.)

Showing the results of reflective thinking in scientific discovery
Treating science and technology in their proper social context
Pointing out alternatives to intelligent group action in the solution of social problems

10. A student who *is socially mature*
    - 10.1 Feels social responsibility and
      - 10.11 Contributes to the general efficiency of the school as an organization
      - 10.12 Is on time with regular and special reports on information which the class needs
      - 10.13 Participates in discussion
      - 10.14 Cares personally for books and equipment used by the class
      - 10.15 Serves in any special capacity to which he is elected or appointed

SUGGESTED CLASSROOM PROCEDURE

Development of *esprit de corps,* setting high standards for the group (The teacher must live up to them himself and expect others to do so.)

    - 10.2 Is sensitive to other people
      - 10.21 In the class
        - 10.211 Praises his classmates for good work
        - 10.212 Finds good qualities in those who are unlike himself

SUGGESTED CLASSROOM PROCEDURE

Judicious praise from the teacher
Discovering the unique contributions which each student can make
Having the teacher step in to protect and encourage a submerged member of the class (This requires tact on the teacher's part.)
Developing a realization and appreciation of individual differences

10.22 In the school
- 10.221 Speaks proudly of "our department" and the contributions it can make to school life
- 10.222 Does not display jealousy or petulance toward teachers and other students
- 10.223 Is conscious of the contributions of all departments in the school

Suggested Classroom Procedure

Showing respect for the subject-matter contributions of other specialists
Constructive attitude (on the part of the teacher) toward all school activities

10.23 In his home
- 10.231 Cheerfully does his share of home duties
- 10.232 Does not impose on others
- 10.233 Makes allowance for the failings of others

Suggested Classroom Procedure

Considering backgrounds and problems of parents and children
Suggesting (to parents and children) family sports and recreation

10.24 In the community
- 10.241 Is interested in civic problems (government, housing, etc.)
- 10.242 Speaks of working conditions during trips to factories, etc.
- 10.243 Makes it a point to talk with others about their work and interests
- 10.244 Judges social and economic situations by spiritual as well as material standards

Suggested Classroom Procedure

Searching for projects of community concern in which adolescents can participate (Helpful in this connection, for the teacher, is Paul R. Hanna's *Youth Serves the Community*.)
Making the acquaintance of many people in the community, introducing students to them in the classroom, and in public institutions, factories, utilities plants, etc.
Pointing out the contributions of individuals in the community to our economic, industrial, and social life

10.25 In the world
- 10.251 Has no racial or national antipathies
- 10.252 Shows interest in world problems (e.g., prevention of war)

Suggested Classroom Procedure

Stressing of the economic interdependence of the world
Speaking of the contributions of scientists and inventors, statesmen and philos-

ophers—living and dead, of all nationalities—to our present knowledge and civilization; finding stimulating readings of this kind
Attempting to develop an ideal of coöperation in improving our social order

UNIT I

Household Machines and Appliances

Objectives

1. All course objectives, particularly
   - 1.1 Critical thinking
     - 1.11 By presenting examples of the thinking process beginning with student questions
     - 1.12 By using all pertinent materials for the solution of problems (See list of learning materials at end of this unit.)
     - 1.13 By studying and applying factors involved in the evaluation of authority
     - 1.14 By using paper and pencil tests of the type developed by the Evaluation Staff of the Commission on the Relation of School and College, Progressive Education Association
   - 1.2 World picture—relating the student to machines and appliances which he frequently sees and uses but which he does not understand, by developing
     - 1.21 Ability to dissect and reassemble some machines and adjust them or replace worn or broken parts
     - 1.22 Understanding of energy relations in certain machines
     - 1.23 Appreciation of relation of material and design to function
     - 1.24 Appreciation of the men who have made possible the machines in his home: namely, the scientist, the inventor, the engineer, the entrepreneur, the mechanic, the laborer, the salesman, the advertising man, the storekeeper
     - 1.25 Insight into the social implications of mechanization of the home by pointing out
       - 1.251 The saving of time in a mechanized home, giving more freedom to the cook and housekeeper (with the unsolved question of how that time is to be used)
       - 1.252 The lack of opportunity for participation by children in the concerns of the family
       - 1.253 Growing dependence of the home on outside services (as in 1.24 above)
       - 1.254 Increase of industrial specialization in supplying machines, appliances, and services
       - 1.255 The need for understanding the problems of those who supply the home and for coöperating with them
   - 1.3 Self-assurance—by showing the adolescent a way to participate in his home life on an adult level

1.31 By helping him develop expertness in judging the values of machines and appliances used in the home
1.32 By teaching him the use, care, and simple repair of home machines
1.4 Physical health
1.41 By study of sanitation and water supply
1.42 By study of air-conditioning
1.43 By study of adequate home lighting
1.44 Safety from accidents, fire
2. Special objectives
2.1 Development of skill in laboratory manipulations having to do with machines and apparatus
2.2 Furnishing a groundwork of information useful in subsequent units
2.3 Development of skills in reporting problem solution
2.4 Development of skills, when necessary, in grammar, spelling, mathematical computation
2.5 Functional use of mathematics in connection with problem solving

Preliminary Period

1. *The teacher's preview* included a definition of the field of study for the unit, discussion of objectives, a few samples of problems which might arise in the course of the unit, and suggested ways of solving them. Inasmuch as this was the first unit, students were familiarized with their resources for the solution of problems. (These have been listed at the end of this unit, amplifying the customary bibliography.) Direct appeal was made by reference to consumer aspects of home machinery, and conscious efforts were made to show students how learnings from this unit could meet their needs. Thus the idea was developed that, to attain freedom, adolescents must show responsibility and competence. It was pointed out that: participation in home life, easy and expected a generation ago, is difficult today; that this unit might help them contribute to family life through their technical knowledge; that this same technical knowledge should help them to a better understanding of their world and so make them more confident of themselves; and finally, that they must realize that the modern home and its members are much more intimately bound up with society than was the case a generation ago.

There is no best order for presentation of these points; in fact, variation from unit to unit is probably advantageous. Since one of the purposes of this preview is the awakening and focusing of interest, the teacher should not hesitate to make use of spectacular demonstrations or material with strong personal or emotional appeal. In this unit, for example, one might show the heating effect of an electric current with a long piece of high resistance wire strung across the classroom;

or a dissected machine can be demonstrated. Slides or a motion picture may be shown, or one may lead off by reading and discussing a chapter or an article dealing with social or economic aspects of mechanization.

2. *Class discussion* brought out such questions as the following:

What is a machine? (Our definition: A machine is a device for securing an advantage from force, velocity, or direction, or for changing one form of energy into another.)

What is the difference between a machine and a tool?

What are essential differences between a machine civilization and a tool civilization?

What are some consequences of mechanization of the home?

What are some of the esthetic, social, and economic effects of mass production?

When were standard parts first introduced?

Are machines really complicated?

How is the automobile constructed?

How does a light bulb change electricity to light?

Is a fountain pen a machine?

Is a toaster a machine?

3. *An inventory of machines found in the home* was begun in class and continued at home. It resulted in the establishment of the following list: faucets, drains, knives, forks, can openers, egg beaters, ice and mechanical refrigerators, gas and electric stoves, toasters, waffle irons, electric clocks, fireplaces, tongs, electric fans, vacuum cleaners, pianos and other musical instruments, phonographs, radios, thermostats, radiator valves, light switches, sash weights in windows, window fasteners, doors, fountain pens, window shades, typewriters, pneumatic doorstops, Yale and Corbin locks, door bells, hall clocks, telephones, shears, stairs, sewing machines, clothes wringers, washers, mangles, electric irons, electric heaters, curling irons, bottle warmers, traps (in tubs, toilets, washbowls), ball valves in toilets, general heating and air-conditioning systems, hot-water heaters, meters (for gas, electricity, water), wiring, lights, "shop" tools (such as braces, bits, hammers, saws, planes, chisels, vises, clamps, pliers, wrenches, screws, nails), power tools (motor, transmission, etc.), wheelbarrows, hoes, shovels, spades, lawn mowers, rotary lawn sprinklers, automobiles, guns, boats, tennis rackets, golf clubs, cameras, movie projectors.

4. *Organization of this material* centered around problems developed from interests which had been expressed by the students. The list of interests expressed was as follows:

piano, 3 students
violin, 1 student
phonograph, 2 students
radio receiver, 2 students
electricity in the home, 3 students
clocks, 1 student
firearms and projectiles, 1 student

camera and photography, 2 students
automobile, 8 students [1]

The first four interests were grouped together as "acoustical machines." The students interested in these were retained for a first conference while the rest of the class went to the library to begin collection of a bibliography. With considerable help from the teacher, the following problems were set up for the group:

What have physics and chemistry done for music?
In improvement of instruments,
by furnishing materials?
by suggesting changes in design?
by inventing new instruments?
by designing auditoriums? [2]

The violin student was sent to the library to look through Dayton Clarence Miller's *The Science of Musical Sounds,* and he came back with a few problems. The boys interested in radio were advised to work with both the acoustics group and the electricity group. They were then sent to examine an old receiver. The girls interested in the piano continued their discussion with the teacher and by the end of the period the following questions had been set up:

GIRL A: Harmony. History of the Piano. Effect on Home Life

1. What is the physical scale?
2. What is the tempered scale?
3. What is concert pitch?
4. What is international pitch?
5. Twenty to fifty years ago, families and friends used to gather around the piano to sing. This is comparatively rare today. Why? In families which enjoy music, does a piano help to keep the family members together? (This was treated as an essay.)
6. What were some of the forerunners of the piano? How were these instruments constructed? How did their music differ from that of the piano?
7. How can different effects be obtained on the piano?

GIRL B: Construction and Operation of the Piano

1. How does striking a piano key produce a tone?
2. What determines the pitch of a sound?
3. What determines the loudness of a sound?
4. Why and how does a piano note sound different from the same note played on a violin? A flute? A trumpet?
5. Why does a piano have three strings for each note?

[1] It will be noted that this does not begin to cover the possibilities set down in the inventory in section 3; many of the remaining machines, however, were studied in subsequent units, especially in Unit III.

[2] It is the experience of the author that students in their early attempts at the definition of a problem, have difficulty in phrasing their questions in such a way that procedures of solution are indicated. It required considerable help from the instructor to formulate the above list. It must be recognized that in early attempts at problem-solving considerable guidance is necessary at every step.

6. Why are the strings of varying thickness?
7. What is the purpose of the pedals? How do they accomplish their purpose?
8. Why does a string sound louder when struck on a piano than when struck outside the piano?

GIRL C: Manufacture, Purchase, and Care of the Piano

1. How is a piano tuned?
2. What are the effects of wide temperature changes on pianos?
3. How can you stop pedal squeak?
4. Why are some pianos more expensive than others?
5. How much work is done with hand tools in piano manufacture?
6. How much by machine?
7. What materials go into a piano?
8. Where do these materials come from?
9. What properties must they have?
10. How can you judge the quality of a piano?
11. Are the most expensive pianos best? Is there a fair relation between value and cost?

The girls were then sent to an old piano to take it apart and become familiar with it before beginning their study. Since the teacher was not expert in this field, the girls were advised to consult the manager of a local piano store.

This kind of organization was used by all groups. Problems were developed around the following outline:

1. Ability to dissect and reassemble
2. Ability to trace energy through the machine
3. Appreciation of relation of design to function
4. Intelligent consumption
   - 4.1 Buying—suitability, quality, relationship between value and cost
   - 4.2 Operation—efficiency, cost of operation, proper care
   - 4.3 Repairs—adjustment, replacement of worn or broken parts
5. History of development—contributions of scientists and inventors
6. Social-economic aspects (when applicable and when information is available)
   - 6.1 Production
     - 6.11 Raw materials—sources, quality control
     - 6.12 Tariffs, warfare
     - 6.13 Competition vs. monopoly
     - 6.14 Quantity production
       - 6.141 Place of the artisan
       - 6.142 Standard parts
       - 6.143 Assembly line
       - 6.144 Tariff protection and other factors affecting cost
       - 6.145 Health and safety factors
       - 6.146 Profits, wages
     - 6.15 Efficiency (Is it the best possible machine for the purpose?)
   - 6.2 Distribution
     - 6.21 Advertising
     - 6.22 Merchandising methods
     - 6.23 Ability of the consumer to buy

6.3 Consumption
6.31 Efficiency
6.32 Effect on living conditions
6.321 Leisure—how used
6.322 Habits of buying, work and play
6.323 Family relations
6.324 Relations with others outside the home
6.325 Health

Work Period

Investigations were begun, using all possible sources of information. The piano group made sonometers, demonstrating the laws of vibrating strings. It assigned readings on sound in a physics text for the entire class. It made several trips to the piano store, ordered a new book for reference, made working models of the action parts of upright and grand pianos. Notes were made on readings.

Meanwhile, the radio group was tearing a radio set apart and putting it together again. It ordered parts for a short wave set. It read up on AC currents and demonstrated transformers and condensers to the class.

The automobile group was soon given a car from the junk yard. The group members worked on it in an old barn and expected to have it in running order "sometime during the year." At the same time they were reading up on highway safety and agitating for a drivers' club in the school. They went to physics texts for information and explanation. One boy borrowed a book on automobile mechanics from the public library and found it more useful than an elementary physics text.

All investigating groups kept "vocabulary lists" of words which required special explanation or laboratory exercises to be understood beyond mere verbalism—for example, force, energy, E.M.F., volts, frequency, amplitude, etc.

One day a week was given over to class meetings during which every one did the same thing. The teacher stepped in when necessary to add assigned work which would clarify any points.

Report Period

About a week was required for giving reports and demonstrations. The piano group took the class to its dissected piano and lectured while it demonstrated. The girls who had studied the precursors of the piano were ready with a lecture, illustrated with original slides, showing the action and parts of these instruments. The violinist gave a demonstration of harmonics and various other effects, explaining each time the physical principles involved. The automobile group took the class to the barn and traced energy through the wiring system, showed the action of the valves, the pistons, the cam and crank shafts, the transmission and the differential. There were charts and diagrams on

the wall showing torque and the action of parts which were difficult for the class to see in the car itself. Throughout these reports there was a minimum of verbalization, because physics was being studied in connection with the thing itself.

Evaluation Period

Fact tests were given on questions submitted by the various groups and edited by the teacher. (Students and teacher took notes during the work period and the report period.) The teacher gave other forms of paper and pencil tests purporting to measure growth in the realization of objectives.

At every step in the unit the teacher asked himself if this material or that activity of the student was contributing to the realization of the unit objectives and to the general aims of education. Was it meeting adolescent needs? Was it developing worth-while personality traits? Was it orienting the student in the basic relationships of living?

Answers to these questions can come only from the observation of student behavior at home and at school. Close parent-teacher rapport will provide the teacher with an answer as to changes at home. Objective tests, anecdotal records, and the student's own self-criticism will shed further light on growth within the objectives which have been set up. Consideration of these results will help decide content and activities in the next unit.

Types of Understandings Developed in This Unit

It did not seem consistent with the objectives of this course to set up ahead of time any minimum essentials in the form of a list of concepts or understandings which were expected of all. Following, however, are *samples* of understandings which grew out of the work. They fall into two classes: those dealing with physical science, and those connected with other areas such as economics, sociology, history, contribution of science to the arts, etc.

Generalizations in Physical Science

1. Matter can be neither created nor destroyed, but can be changed from one substance into another.
2. Energy can be neither created nor destroyed, but can be changed from one form into another.
3. In every transformation of energy some goes into heat and is dissipated.
4. The efficiency of a machine may be computed by dividing the output by the input.
5. Most machines are very inefficient.
6. The quality of a musical note depends on the number and character of its overtones.
7. An electrical charge in motion produces a magnetic field about the conductor.
8. The volume of a gas increases with heat and decreases with pressure.

Generalizations in Other Areas

1. An outstanding characteristic of our civilization is the widespread use of machines.
2. Wide distribution of machines requires that they be both cheap and efficient.
3. Cheapness and efficiency are possible only by
   - 3.1 Intelligent design with standard parts which require accurate measurement
   - 3.2 Large-scale production which necessitates coöperative effort in financing, managing, and operating an industry
   - 3.3 A market with a large buying power; that is, a high standard of living
4. Practically everything in the home has been made and is serviced by outside agencies.
5. Applications of science have had important effects upon the functions and relationships of the family.
6. Adolescents share with their parents the responsibility of finding shared recreational activities which bind the family together.
7. Price is not a reliable index to value of household machines.
8. Advertising is not a reliable source of information as to the value of machines.
9. The modern machine is the result of centuries of work by men both famous and obscure.
10. Some of the greatest industrial organizations in the world are engaged in the production of machines for the home and for personal use.
11. Mechanization of the home has helped create our present labor problems.

Learning Materials Used in This Unit

1. Machines

   As many as possible of the machines listed above (Preliminary Period, 3) should be available in the laboratory or in a store-room or shop.

2. Working models and charts

   Various types of drain traps may be illustrated, using glass tubing and wide-mouth bottles. Parts such as the action of a piano note, difficult to see *in situ,* may be removed and mounted. In the discovery of materials, everything depends on the ingenuity of the teacher and the students. There is no collected bibliography of this kind of material so far as is known.

   Models prepared by commercial concerns for distribution to schools are not well publicized. Writing to manufacturers often brings free material or description of low cost material. It is understood that the following materials are now being distributed free.

   Storage battery—Electric Storage Battery, Philadelphia, Pennsylvania, will send cut-away storage battery, explanatory pamphlets, and large chart, free.

Dry cell—National Carbon Company, New York City. Cut-away Columbia dry cell, free.

3. Experiments

These are of two types:

3.1 The routine laboratory exercises which are probably justifiable because they give students experience, particularly kinesthetic experience, with simplified applications of principles. These exercises are found in all laboratory manuals. They should probably be card-catalogued from several sources or torn from the books and mounted on manila cardboard and filed in the laboratory. An insufficient supply of direction sheets, like too few sets of apparatus, need not preclude individual laboratory work. It is not necessary that the same experiment be performed by all students at the same time.

3.2 Experiments to discover a principle or relationship or to test one which is doubtful require individual techniques that must be worked out by pupil and teacher.

4. Charts and diagrams

Those made by students and: DC ammeter, AC ammeter, wattmeter, 16″ x 18″ each, Weston Electrical Instrument Company, Newark, N. J., free.

Carburetors. Two charts 16″ x 21″, Zenith Carburetor Co., Hart Avenue, Detroit, Mich., free.

Two charts in color, 32-page book, *The Stromberg Plain Tube Carburetor,* Stromberg Motor Devices Co., 58 East 25th Street, Chicago, free.

Heating systems. Two charts 18″ x 27″, Automatic Storage System and Automatic Water Heater, Ruud Manufacturing Co., Pittsburgh, Pa., free.

Refrigeration. Chart in colors 11″ x 14″ showing refrigerating cycle, Copeland Co., 1331 Holden Avenue, Detroit, free.

5. Lantern slides

5.1 Made at school:

Lantern Slides, How to Make and Use Them, Eastman Kodak Co., Rochester, N. Y., free.

Materials for making: Eastman Kodak Co., and Radio Material Slide Co., 1819 Broadway, New York City (material on which text may be written).

5.2 For sale:

Keystone View Co., Meadville, Pa., Science Catalog No. 27.

W. M. Welch Scientific Co., 1515 North Sedgwick Street, Chicago. Catalog L.

Williams, Brown and Earle, 918 Chestnut St., Philadelphia. Teachers' Guide.

5.3 For rent:

Detroit Publishing Co., Detroit, Michigan, catalog.

5.4 Free loan:

Write to state museums, universities, and Department of Education in your state.

Refrigeration: General Electric Co., 1 River Road, Schenectady, N. Y. 38 slides on the History of Refrigeration.

Incandescent Lamp, History of. General Electric Co.

Light and Vision. 22 slides. General Electric Co.

Mechanics. 38 slides. General Electric Co.

6. Film strips

General Electric Co., 1 River Road, Schenectady, N. Y.:

Electricity on the Farm

100-Kilowatt Vacuum Tube

Vacuum Tubes

Heat

Pictorial Library, Society for Visual Education, 327 South La Salle Street, Chicago, catalog.

7. Motion pictures

Bibliography:

Suggestions and Bibliography on Motion Pictures, National Congress of Parents and Teachers, 1201 16th Street, N.W., Washington, D. C., 15 cents.

Visual Instruction Bulletin, Department of Education, Columbus, Ohio, free.

Free loans:

U. S. Bureau of Mines, Experiment Station, Pittsburgh, Pa., catalog.

Y.M.C.A. Motion Picture Bureau, 347 Madison Ave., New York City.

General Electric Co., Schenectady, N. Y.

Douglas D. Rothacker Industrial Films, 729 Seventh Ave., New York City.

8. Opaque projection

Balopticons serve as excellent projection devices in rooms which can be sufficiently darkened. The great advantage is the speed and ease of preparation of mounts. Pictures, diagrams, etc., may be clipped from books and magazines and become available to an entire class at once while they are being described by a lecturing student or teacher. Student drawings may be used or pages of an open book or any objects which are not too thick.

9. Field trips

The use of field trips is discussed briefly in connection with Unit IV below. The teacher will find it convenient to have a list of local excursions, including trips to museums, factories, mills, etc., with descriptions of what is to be seen.

10. Books

Bailey, E. H. S., *A Text-book of Sanitary and Applied Chemistry,* 4th ed. (New York, The Macmillan Co., 1917).

BALDERSTON, L. R., *Housewifery,* 5th ed. (Philadelphia, J. B. Lippincott Co., 1936). Useful because of emphasis on efficiency.
BUTLER, A. M., *Foundations of Physics* (Boston, M. Barrows and Co., 1934). Considerable emphasis on household physics.
CHURCHILL, A. L., and WICKENDEN, L., *The House-Owner's Book,* Rev. ed. (New York, Funk and Wagnalls Co., 1928).
COSGROVE, J. J., *Principles and Practice of Plumbing,* 3rd. ed. (Scranton, Pa., Technical Book Publishing Co., 1922).
DERR, L., *Photography, for Students of Physics and Chemistry* (New York, The Macmillan Co., 1906).
FURNAS, C. C., *The Next Hundred Years* (New York, Reynal and Hitchcock, 1936). Useful for boys with shop interest.
HOLLEY, C., and LOHR, V. C., *Mastery Units in Physics* (Philadelphia, J. B. Lippincott Co., 1932). Brief explanations of many household machines.
KEENE, E. S., *Mechanics of the Household* (New York, McGraw-Hill Book Co., 1918).
LYNDE, C. J., *Physics of the Household* (New York, The Macmillan Co., 1914).
MILLER, D. C., *The Science of Musical Sounds,* 2nd ed. (New York, The Macmillan Co., 1922). Valuable for advanced students.
PEET, L. J., and SATER, L. E., *Household Equipment* (New York, John Wiley and Sons, 1934).
SEDGWICK, W. T., and TYLER, H. W., *A Short History of Science* (New York, The Macmillan Co., 1917).
TRAFTON, G. H., *Science of Home and Community,* Rev. ed. (New York, The Macmillan Co., 1926). Part I deals with science of the home. A general-science text, but useful in sketching social background and in its common-sense method of exposition.
WILLIAMS, A., *How It Works,* Rev. ed. (New York, Thomas Nelson and Sons, n.d.). Out of print.

11. Pamphlets

Manufacturers of equipment will usually supply pamphlets describing their products. It should be remembered that these are not impartial descriptions.

Better Buymanship Bulletins, Household Finance Corporation, 919 North Michigan Boulevard, Chicago. (With bibliographies.)
No. 14: "Electric Vacuum Cleaners."
No. 19: "Household Refrigerators."
No. 20: "Home Heating."
Consumers' Guide.
Consumers' Research.
OGBURN, WILLIAM F., *You and Machines* (Washington, D. C., American Council on Education, 1934).
Sears, Roebuck Co., Chicago, Manuals on Plumbing and Heating.
City Regulations: Plumbing, Electricity, Gas, etc.

UNITS II–VI

Unit II. Household Supplies

The plan of this unit is, in most particulars, like that of Unit I. The same steps are followed in much the same way. The two units are separated only as a matter of convenience. Inclusion of the material from both in a single unit would have resulted in a somewhat unwieldy mass. The separation is on the basis of subject-matter emphasis—physics in Unit I and chemistry in Unit II. The second unit deals with materials and fabricated products brought into the home or used elsewhere by adolescents. The following list shows the kinds of things studied:

Kitchen utensils and cutlery
China and crockery
Glassware
Table silver
Foods and beverages
Soaps and cleaners
Cosmetics
Medicines
Fabrics
Rugs and linoleum
Ready-made clothing
Shoes
Stockings
Coal
Wood
Oil
Furniture
Bedding
Linens
Toys
Stationery
Books, newspapers, magazines
Paint, varnish, shellac, wallpaper

If any student evinces interest in them, the list might be extended to include some of the materials of which the house itself is constructed. It may likewise include materials used in sports and hobbies.

Most of the objectives of Unit I apply here. There is even more emphasis on buying and using than in Unit I. Many products ordinarily bought can be made in the laboratory at a fraction of their cost at a store. This is an excellent opportunity to analyze selling prices and the entire economic process from production through sales to the consumer.

Foods and textiles are tested for adulteration; fuels are studied in connection with efficient combustion; practical laundering, cleaning, and spot and stain removal are given their rational basis in chemistry. The technology of manufacture of many products is taken up by those interested. Students interested in the arts may legitimately take time to make pigments and glazes.

Physics is used to explain the properties and uses of various commodities—clothing, glassware, bedding, and detergents. If the heating system was not taken up in Unit I, it may be studied here—and also the water supply, or the latter may be placed in Unit III.

The social-economic aspects of commodities, processed or manufactured, are considered here as elsewhere; also scientific development which has made the commodities available in their present form. There is some attempt to go into the history of the commodities themselves or the classes they represent; as for example, soaps and cleaners, cosmetics and medicines. A biologist can be called in, or a physician, to discuss the hygiene of these articles. The average physician, however sound his ideas may be on dosing with drug-store remedies, is not necessarily expert on soaps and cosmetics. It might be wise to ascertain his views and approach before asking him to discuss these. If one is fortunate enough to obtain speakers from outside the school, their talks afford an excellent opportunity for an exercise in evaluation of authority.

The groundwork of chemistry is developed in connection with functional understandings. After the original set-up of the problems, these are divided, with subheads carried to the point of chemical principles involved. Assigned readings and laboratory work thus contribute to the solution of real problems.

Unit III. Public Utilities

In the first two units, things were studied at home and brought into the laboratory. In this unit and in Unit IV, it is necessary to go outside the laboratory for these first-hand experiences. Field trips are arranged to see as many as possible of the following utilities:

Telephone (The telephone company will lend instruments to the school.)
Telegraph (Telegraph sets can be simply made by students.)
Radio (The receiver has already been studied.)
Electricity (This utility and others are related to machines of the first unit.)
Water
Sewage disposal
Gas
Street-car
Bus
Railroad
Airplane

(To indicate the point of view of this course, the airplane should not be studied *because* it is a "modern marvel," but only *if* any one in the class has had considerable air travel or otherwise shows an interest in aviation.)

If the study is worth while, it should be thorough. Each student should study at least one utility thoroughly. This means several trips to plants, offices, shops, etc., and the class schedule should be modified to provide for this. If it is impossible to arrange for a large number of trips during school time, most students will be found sufficiently interested to go after school and on Saturdays. Every student will have specialized in one utility during the unit and should be a competent guide for later trips of the entire class.

A procedure that has been found successful is to take the entire class during the preliminary period to several utilities plants, a list of problems for study having been previously developed. Additional questions are listed during the visit. At the next class meeting, these questions are collected and organized, then turned over to committees who select individual utilities for study. Reading and laboratory work, in addition to field trips, is directed toward solution of these problems by interested committees for two or three weeks. The entire class is then assigned such study as may be necessary for subsequent understanding of the presentation at the plant by the special committee. A second trip toward the end of the unit by the entire class brings the realization that they have come a long way since the beginning of the unit. Parts and processes have been clarified, and the student has gained assurance from understanding a formerly unknown part of his daily life. Moreover, his learnings are not limited to physical science, for the teacher has provided for human contacts as described in Unit IV.

Unit IV. Representative Industries

The emphasis should be on local industries with a large part of the time spent in consulting people engaged in them. For this unit the teacher should become familiar with the mills or factories or farms or mines which support the community. (Of course he should already have done so anyway!) He should know the men engaged in these industries—miners, farmers, mechanics, laborers, foremen, clerks, salesmen, executives, chemists, and engineers. In a small

town, this should be fairly easy; in a large city, one may consult the Chamber of Commerce and the classified telephone directory. Local labor organizations are usually sympathetic if they can understand what the teacher is trying to do. There is no community completely deficient in industries, of course, unless it is within commuting distance of an industrial center.

Where raw materials are produced, it is necessary, if the process is to be seen as a whole, to follow them through packing or fabrication, step by step, to the consumer. In manufacturing centers, the process must go backward and forward. The effort is to *personalize* the process as much as possible from production to consumption. Pupils should know the origins and destinations of all materials handled by the industry; they should observe loading and unloading, the operations of research and testing laboratories, the preparation of raw materials, the manufacturing process, an assembly line. They should talk with officials and workers—the teacher's friends—about research, technology, and social and economic problems.

Objectives, in other words, include not only an understanding of scientific principles and technical processes but a sensitiveness to such social-economic problems as distribution, the scale of living, working conditions, immediate relations of capital and labor, the implications of industrial policies for war and peace. This sensitiveness, it seems, can be developed only through personal acquaintance with many kinds of people, particularly those of a "class" sometimes felt by adolescents to be hostile toward them.

Finally, this social-scientific-technological-economic point of view should be carried back into the past in order to trace the development of specific industries and our civilization as a whole, and into the future to predict the probable outcome of present policies and problems.

Unit V. The World Picture

The purpose of this unit is to help the young person develop certain attitudes toward his world. Concepts of efficiency, first developed in Unit I in connection with machines, have found contributions from each succeeding unit drawn from physical science and from economic and social organization. Here there is oppor-

tunity for a broader application of the term in conservation of mineral resources and in efficient adaptation to earth forces and characteristics.

Personal efficiency involves consistency of outlook and a realistic view of the universe. It also involves operational thinking. Attempt has been made throughout these units to contribute to a student's personal philosophy and to his personal efficiency, but in this unit can be found the broad field necessary for a philosophical overview of human life. Questions of religion have a way of coming up during a reconstruction of the history of the earth and consideration of the stars. There are here plenty of examples of operational thinking—and lack of it—by astronomers and astrophysicists. Evolution and relativity make their contributions here to the world picture.

This bird's-eye view of his world permits the adolescent to see the earth as the home of living things, as a source of raw materials for industry, and as our immediate source of energy. It shows him the forces and motions which control tides and orbits, winds and ocean currents, and give us seasons, day and night, and our very unsatisfactorily timed year.

Unit VI. Matter and Energy

This unit serves as a review of the year's work and as groundwork for the more formal courses in chemistry and physics (one semester each) which may be elected during the senior year.

III. UNIT ON PUBLIC HEALTH

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Introductory note by the Committee. This unit on public health is the last unit of a three-year health-instruction program at the University of Wisconsin High School in Madison, Wisconsin. Although most of its material is drawn from biology, the course includes some material from physics, chemistry, and psychology, and this first unit deals with some topics from the same sciences. If we were to attempt to place the course in the classification discussed in Chapter X, it would probably fall under the heading of broad field courses, but the classification does not suit this course very well. We would call attention particularly to the range of understandings to which this unit may contribute, to the variations of work possible for different students in the class, to the first-hand acquaintance with the life of the community promoted by this kind of work, and to the variety of evaluation procedures worked out by Mr. McMullen as an important part of the unit.

I. *Purpose and Point of View*

The purpose of this summary is to illustrate how an existing unit of work was revised and enriched, using the philosophy and some of the materials provided by the earlier tentative issues of this report.

The original unit had been written and used in teaching for one year before we had an opportunity to read the report. The first revision was made after a study of the report in its 1936 form. A second revision was made after a study of the later (1937) issue. The report influenced the unit in three important ways. In the first place, many of the interpretative generalizations listed were found to be directly usable, and several more were suggested by those in the report (Section VII). Second, the formulation of ob-

jectives as "desirable characteristics of personality" was found to be convenient and suggestive; in particular the discussions of social sensitivity, of coöperation, and of reflective thinking were found useful (Section VI). In the third place the close linking of evaluation with curriculum design, which was characteristic of the report, aided in the development of several of the evaluation instruments used in this course (Section VIII).

Many of the desirable outcomes of this unit may not be evidenced until the pupil can participate actively in community life. This will in many cases be delayed until graduation from college. His reactions to problems of public-health significance will be the most reliable measure of the success of our teaching. If we have developed in the pupil an appreciation of the understandings listed in this report, then he should act more intelligently and for the common good of society in issues pertaining to public health. We believe that he will. This assumption is our only justification for the unit. We had previously been concerned in our health teaching in this course with the solution of problems dealing with the immediate and probable future personal needs of the student. In this unit we are stressing the desirability of his intelligent participation in health measures that will insure not only his own personal well-being but that of his neighbors as well. We are attempting to develop sensitivity to significant social health problems. Pupils are usually much interested in bettering themselves but their need for contributing to the betterment of society in general is not always so acutely felt. Their willingness not only to support and campaign for better methods of public-health control but also their insistence upon the proper handling of such problems as infectious disease control, adequate and good water supplies, proper and prompt removal of wastes, care of the indigent sick, better medical care through lowering of costs, industrial compensations, etc., will be one important criterion by which we may judge the success of the teaching methods used in this unit. Another more immediate method of measuring results is through the use of certain evaluation instruments preceding, during, and at the completion of the unit. Some of the instruments that have been used and some that are being developed are more fully discussed in this report under evaluation (Section VIII).

II. *Place of the Unit in the Health Program*

This is the final unit in the three-year health program at the University of Wisconsin High School. The work previous to this is primarily confined to the personal and racial branches of hygiene and includes material organized around the following broad units:

10th year	Adjustment to School Program Posture Sex Hygiene Skin Infections and Irritations	3 55–minute periods per week
11th year	Proper Diet Digestion Care of Foods Purchasing of Foods Temperature Regulation Disease Control and Prevention	2 55–minute periods per week
12th year	Mental and Emotional Hygiene Heredity Community Health and Sanitation	2 55–minute periods per week

Prevention of accidents and first-aid measures are discussed at appropriate points throughout the entire course.

III. *Objective and Major Understandings*

The *objective* of this unit is to help each pupil develop an increasing sense of personal responsibility for the health of the community as well as for his own well-being.

We believe that the problems in this area presented to the pupil contribute primarily to his understanding in the third basic aspect of living, namely social-civic relationships. That contributions to the other basic aspects of living are made simultaneously is evident in the list of understandings that follows. We feel that it is particularly worth while that the pupil develop an appreciation of the contributions of science in social-civic life, since orientation of the pupil in this relationship has been a need that has not been met particularly well in many of our conventional science courses.

These are the *understandings* that were considered of primary importance in the original working out of the unit.

1. Public hygiene has been, in the past, and to a great extent still is, useful chiefly in the prevention of acute infectious diseases, while individual hygiene has been concerned primarily with the prevention of chronic illnesses. The alarming increase in the number of deaths due to chronic diseases, such as heart disease and cancer, has necessitated action on the part of public hygienists resulting in more public education and the establishment of clinics for the diagnosis and treatment of these diseases.

2. It is believed that it is within man's power to rid himself of all infectious disease.

3. The people, constituting the consumers, have it in their power to accomplish many of the necessary reforms that are needed in public hygiene.

4. Individual health is impossible to maintain in a large community without the organized help of each member of the community.

5. Many branches of science contribute to the advance made in public hygiene.

6. Present methods of public regulation of food and drugs are inadequate, and new provisions must be made if the consumer is to receive satisfactory protection.

7. Semi-public hygiene (maintained by institutions and industrial establishments) is as essential to the health of the community as is public hygiene.

8. The amount of public education and research on important problems that a health department does in excess of the routine regular work that it is required to do may serve as one reliable index of its efficiency.

9. Vital statistics indicate that control of infectious diseases has been one of the greatest contributing factors in increasing the average life span.

10. Attitudes concerning the causes of diseases (punishment for sin, demoniac possession, and other taboos) still interfere with their intelligent control (insanity, syphilis, tuberculosis, etc.).

11. The health of every individual should be a matter of social concern and responsibility.

12. The securing of adequate, scientific medical service by all people is one of the outstanding social problems of our day.

It is clear that no one student attains a maximal grasp of all these generalizations especially since each student is working on a different problem, and since they all have a wide variety of needs in the first place. But the broader generalization will in some measure affect the behavior and intellectual life of most of the students. Section VII of this summary contains the generalizations from the report that are also being used.

IV. *Organization and Presentation of the Unit*

Two types of activities are included in this unit—those carried on by the class as a whole and individual projects selected by the pupils according to their interests. The unit is introduced by means of a class study of vital statistics, the history and prevalence of disease, the cost of sickness, and the changes brought about in man's environment by his desire to live in large communities. The annual reports of the local Board of Health are used in studying these factors in a situation which is close to the pupil. From this study the need for organization and coöperation on the part of the members of the class is apparent if the study is to be completed in the allotted time. To meet this need, the work is apportioned to the class according to particular interests, and individual studies are started. Some of the departments and agencies investigated include the following:

1. Municipal inspectors of dairies, food, housing, shops, etc.
2. Municipal diagnostic laboratories
3. City welfare department
4. Contagious diseases hospital
5. Visiting nurses organization
6. School nurses organization
7. Social worker nurses organization
8. Attic Angels organization
9. City dental clinic
10. Industrial nurses
11. Open-air schools
12. Kiddie camp
13. Family welfare department
14. City hospital
15. Venereal disease clinic
16. Chest clinic
17. Vital statistics department
18. Private hospitals
19. Private clinics

A similar study is made of the state departments concerned with promoting public health, and a brief study is made of the work being done by the League of Nations in relation to public health.

The procedure in the individual studies conforms to the general outline that follows, with some modifications in the case of certain reports.

1. Selection of a department, branch, or organization for study (Reasons for the selection)
2. Listing of problems that the pupils would like to solve (Instructor checks and suggests problems that may have been omitted by the pupil)
3. Arranging for a visit or interview
4. Visiting the department and completing the interview
5. Further visits or actual participation in the work of the department may be desirable in some instances
6. Writing the report (Checked by English instructor)
7. Comparison of the work being done locally with the work of similar departments in other localities (Comparison charts) [1]
8. Oral summary of the report to the class
9. Class discussion
10. Evaluation of the report (Instructor confers with the pupil)

The problem of supplying adequate medical care for all income groups becomes apparent from such a survey of the present available agencies, and a study of how the problem might better be solved becomes one of interest to the pupil at this time. Consequently a study of the plans that are being proposed for meeting the medical needs of individuals and groups in a more satisfactory manner are considered by class discussions of the following problems:

1. What is the present situation in medical practice?
   a. As it affects the patient.
   b. As it affects the doctor.
   c. As it affects the community.
2. What are the possible solutions?
   a. Continue the present system of private practice and limited community responsibility.
   b. Promote voluntary group medicine and insurance.
   c. Promote a system of compulsory health insurance.
   d. Adopt a system of state medicine.
3. What is the ratio of physicians to total population in the United States and elsewhere?
4. Are there communities without physicians?

[1] In the case of the local reports each pupil selects a city in a different geographical location and compares its problems and the methods of attack being used to solve them with those being used in Madison. The information necessary for the comparison is obtained by the pupil through correspondence with the officials of the department in the city he selects.

A similar comparison is made in the study of state departments, but in this case he need only consult the annual health reports that are kept on file in the library for information about another state's methods of dealing with the same or a similar problem.

5. What percentage of the population does not receive medical care and what types of care are most needed?
6. What is the relationship between income and medical care?
7. How much is spent for medical care and for what is it spent?
8. How does this compare with money spent for other purposes?
9. Is the burden of cost of medical care properly distributed among the different income groups?
10. Why is the problem of self-medication becoming more urgent in this country?
11. To what extent is the government now a competitor of the private physician?
12. How do the number of osteopaths, chiropractors, faith healers, naturopaths, midwives, etc., compare with the number of licensed physicians?
13. What forms of commercial competition must the general practitioner meet?
14. Are the present incomes of doctors adequate?
15. What is the balance between urban and rural practice?
16. What is the problem of fee splitting?
17. Is the cost of preparing for the medical profession justified by the returns?
18. Can private physicians meet the competition offered by clinics and health centers, governmental agencies, private health organizations, school health services, city health nurses, county nurses, free hospitals, Federal agencies, etc.?
19. Are the present medical practitioners making use of all the available facilities for diagnosis, prevention, and cure of disease?
20. Would a program of health insurance result in serious breaches in the desirable relationships between patient and doctor?
21. What effect would state medicine have upon the initiative of our people?
22. How do the present medical associations feel toward the proposed plans for reorganization?
23. What are the plans offered by group medicine or health insurance?
24. How has health insurance worked out in Europe?
25. How has health insurance worked out in rural communities?
26. How has health insurance worked out in cities?
27. How has industrial insurance affected the workers?
28. How does state medicine differ in plan from socialized medicine?
29. In what respects would state medicine overcome the abuses present in our private practice plan?

V. *Class Projects*

In addition to the individual and class problems outlined above, a study is made of the following problems. Those outlined below

are carried on as a class project at the same time that individual projects are under way.

1. How does Madison secure for its citizens a sufficient quantity of pure water? How do these methods compare with those used in other cities in the United States?
2. What are the recognized methods for removing and destroying city refuse? What methods are employed in our city?
3. How does Madison solve its sewage disposal problem and how do these methods compare with those used in other cities?
4. In what ways has the state aided in overcoming pollution problems in Wisconsin? How have industrial organizations aided in solving their own waste disposal problems?

In each of the above problems, the following points are stressed in arriving at a solution.

1. History of the department, reasons for changes in operation and control
2. Study of the science principles involved in the present process and their application in other fields
3. Observations of the related health regulations, reasons for their existence and manner in which they are enforced
4. Opportunity for further improvements or expansion of the present facilities in case of an increase in population
5. Vocational opportunities that suggest themselves to the pupil from his contacts with the men in charge of the work being studied
6. Comparative study of the methods used in our city with those used elsewhere
7. An analysis of the cost of operation and methods by which these costs are met
8. What changes in public opinion will enable this department to function with maximum efficiency?

The past experiences of the individuals in the group determine the emphasis the student places on the different aspects of each problem. Some are more interested in the chemistry and physics involved in the process. Others are concerned with the administration, or the social problems, or the method of financing, etc. Those who have had the traditional chemistry and physics courses aid the instructor in making the applications of the principles from these fields more intelligible to the ones in the group who have not had this previous training. Those who have paid special attention to the social sciences are responsible for helping the others understand the social implications of the problem.

OUTLINE OF MATERIAL INCLUDED IN SOME OF THE PUPIL PROBLEMS

Study of Water Supply

A. *General*

1. Uses of water: Body uses, industrial uses, chemical uses
2. Possible sources: Hygienic considerations, geological and geographical, size of the city, etc.
3. Purification: *Natural:* Sunlight, flow, sedimentation, freezing, filtration. *Artificial:* Consider the following: method, practicability, reliability, cost, efficiency, effect upon the health of the consumer, type of water best suited to the process, and the extent of its use in the United States. *a.* sedimentation and storage; *b.* slow filter process; *c.* rapid filter process; *d.* heat; *e.* biological processes; *f.* coagulating devices; *g.* aerating devices; *h.* disinfection with chemicals; hypochlorite of lime, liquid chlorine, ozone; *i.* disinfection with ultra-violet rays
4. What undesirable substances, that do not make water unwholesome, may be found in a water supply? How are these controlled or removed? Rust, algae, minerals, suspended material, etc.
5. Diseases traced to polluted water: Typhoid, dysentery, etc.
6. Methods of testing water: *a. Chemical:* Color, odor, suspended matter, minerals. *b. Bacteriological:* Quantitative, qualitative, significance of B. coli
7. Swimming pools (public, private): *a.* Regulations: reasons for method of enforcing. *b.* Chemical and physical methods used in maintaining a sanitary pool

B. *Study of Madison water supply*

Organization

1. History of the department
2. Reasons for present methods and locations
3. Organization of present department: control, number of people employed, duties of employees, divisions of the personnel, relationship of department to city, services to city, etc.

Water Supply and Service

1. Geological study of area: Chart and map the geological strata and consider conditions under which each stratum was formed; trace the source of our water supply; depth of wells, limits of the supply.
2. Water cycle: Age of water in unit wells; how determined?
3. Service: Extent of service; areas served; metering

Water Consumption

1. Study of data from Madison and other areas; interpretation of data; effect of metering on consumption; industry; losses from poor systems of distribution, etc.; effect of present methods of living on water consumed, as compared with amounts formerly used

Quality of Water

1. Sources of contamination
2. Bacteriological and physical tests
3. Chlorination
4. Hardness of water: Methods of softening; advantages and disadvantages of municipal softness

Water Rates

1. Demand and water charges; reading meters; construction of meter
2. Comparison of our water rates with those in other cities
3. Uses made of surplus funds

Visit to Pumping Station

1. Types of engines, pumps, compressors, etc.
2. Storage and sedimentation units
3. Pressure problems; distribution

Visit to University Pumping Station

1. Reasons for dual system
2. Dangers of such a system
3. Comparison of pumping, storage and distributing methods with those used in the city

STUDY OF WASTE DISPOSAL (GARBAGE AND STREET WASTES)

1. Methods: Fill methods, incineration, sorting, recovery, hoggery, home disposal methods, etc.
2. What constitutes a good service? Coverage, regularity, organization, avoidance of nuisances, etc.
3. Regulations: Reasons for, need for others
4. Effect of season, depression, growth of city, etc., upon kinds and amounts of garbage
5. Comparison of local methods with those used in other cities; suggestions for improvements in local methods
6. Visit filled areas and report on how this land is being used by the city. What areas in the city need filling?
7. Interview the people in charge of disposal departments and prepare a report on the information acquired.
8. Visit the city hoggery. Report on sanitary conditions. What methods

would be more desirable? How can we contribute to the accomplishment of needed changes?

Sewage Disposal (Study of Present Organization)

1. Reasons for creation of metropolitan sewerage district. What improvements have resulted in Madison, in outlying districts?
2. Organization of business and technical personnel
3. How is the work of the district financed? Assessments for benefits; tax increases; bonding
4. What is the relationship between the city and the district? Advantages? Disadvantages?
5. How have lake conditions been improved? What are the present pollution problems?

General Considerations

1. What is sewage? Sewerage? What is a double sewerage system? Advantages?
2. What is the relationship between water consumed and sewage produced?
3. Why is sewage obnoxious? Dangerous?
4. What bacteria are commonly found in sewage? What two types? How are they classed according to action on organic material?
5. Discuss hydrolytic changes of proteins, cellulose, fats, brought about by bacteria.
6. Discuss reduction as it takes place in sewage. How does this fit in with our understandings of chemical reductions?
7. Discuss oxidations that occur in sewage.
8. What is a biological cycle? How is the cycle disturbed by raw sewage? Effluent?
9. What is the significance of algae in sewage treatment? Polluted waters?
10. What are the factors to be considered when one is looking for a method of disposing of sewage? Is the dumping of raw sewage in streams ever justifiable? Discuss.
11. What is the purpose of chlorination of sewage during treatment? (Visit the sewage disposal plants in Madison.)
12. Explain the operation of each of the following parts of a sewage disposal plant: An Imhoff tank, sprinkling filter system (consider the construction, bacterial actions, physical actions, chemical actions, and efficiency of each part), grit chamber and grease extractor, chlorination unit, dosing chamber sprinkling filter, Dorr Clarifiers, sludge beds.
13. Consider the methods of operation used in the following parts of an activated sludge plant: grit chamber and grease extractor, preliminary settling basins, aeration tanks, aeration control room, final clarifying tanks, sludge digestion tanks, drying beds, gas en-

gine and blower, gas holder, heating system for sludge digestion tanks.

14. What are the advantages of the activated sludge type of treatment over some of the older methods? Gas, fertilizer, odors, flies, etc.
15. What are filter flies? Work out their ecological relationships to the trickling filter beds. Why are they found only in this environment? How are they controlled?
16. The problem of industrial wastes as a complicating factor in efficient sewage disposal is discussed. The advisability of requiring industrial packing plants, laundries, etc., to maintain their own disposal plants is considered by the pupils.

VI. *Some Desirable Characteristics of Personality to Which This Study May Contribute*

A. *Social sensitivity.* It is hoped that the study will help the student to view appreciatively and sympathetically the problems that face others. If human suffering in classes and races other than his own can be made to become the concern of the pupil, this objective will be partially satisfied.

This study should also help to make him more sensitive to his responsibility to help others, by showing him some of the ways in which social problems have arisen because of the unwillingness of certain groups to help others when they were in need.

The study of the great advances made in preventive medicine by the development of vaccines, public clinics, welfare organizations, state medicine, etc., should aid him in developing social sensitivity.

B. *Coöperativeness.* The need for collective efforts in obtaining water, disposing of waste, controlling epidemics, preventing and curing disease as studied in this unit should impress the student with the importance of coöperativeness in our civilization.

The manner in which the study itself is conducted gives the pupil a chance to practise coöperativeness. Realization of the fact that greater progress can be made by the division of labor method in making a community survey should lead the pupil to a better appreciation of the necessity for coöperation in certain types of accomplishments.

C. *Reflective thinking.* An opportunity to apply reflective thinking to social problems, as well as to the basic problems of science that are considered in the unit, should develop in the pupil a respect for this manner of thinking and also an opportunity to

recognize the limitations of the method when one is working with unmanageable materials.

An example of how the student may use the skills required in reflective thinking is shown in a report of the work of the industrial nurse and the safety devices found in a large packing plant. (These examples are taken from a student report. Examples of the same skills could be found in any of the reports made by the students.)

1. Skill in observing phenomena accurately and at first hand. Some observations made by pupils were:
   a. The first-aid station in the factory was centrally located.
   b. The bulletin boards in the factory were covered with "safety-grams" and warnings as to the dangers of certain practices.
   c. The workmen are required to have safety shields on the blades of their knives.
   d. The workmen wear special shoes that keep their feet dry.
   e. Some of the men wear shoes with heels that enable them to work on an incline without slipping.
   f. Each workman is supplied with a set of rules stating what should be done in case of injury.
   g. Safety devices on all machines protect the workmen from injury.
   h. The attitude of some of the workmen toward minor injuries and first aid is one of ridicule, indicating that they do not have an understanding of the real dangers of infection.
   i. It was noted that the company supplies all safety devices and first-aid services for their own protection as well as that of their workmen.
   j. Drastic measures are taken by the company if the workers do not obey safety or first-aid rules.
   k. Workers react unfavorably to safety devices if the device interferes with the speed at which the work can be done. This is especially true in the case of piece work.
2. Discovering and defining problems in the parts of the community selected for study
   a. A student observed a need for the development of safer machinery and felt that there was a need for more instruction as to the significance of rules and regulations laid down by the safety department of the factory.
   b. There is a need for factory managers to consider the safety of their employees before speed of production.
   c. A student suggested that some form of health insurance, in addition to the compensation required by law, might be desirable.
3. Collecting, organizing, and analyzing data. The skill with which the student was able to do this was shown by the manner in which he presented his oral report and the organization of his written report.

4. Skill in drawing inferences and deducing conclusions from data. After study, one student concluded:
   a. The compensation laws resulted in vast improvements in working conditions.
   b. The unionization of workers and their demands for better working conditions were also responsible for some improvements in the conditions under which men must work.
   c. The constant need on the part of the employer to educate his employees concerning the dangers involved in their work is shown by the safety posters as well as by the organization of safety departments in large factories and the employment of factory doctors and industrial nurses.
5. Skill in formulating and expressing ideas orally and in writing (This can be shown in the final written or oral report.)
6. Skill in meeting and interviewing people who may help in solving problems
7. Skill in formulating hypotheses and then testing hypotheses by comparing conclusions with those reached by experts in the field studied. The student, after observing the safety devices used in a large meat-packing factory, believed that many of these safety devices would not have been used if the employer had not required their use. As a means of checking this hypothesis the student visited many smaller meat markets in the community and generally found that where the meat cutter was responsible for his own welfare he was not using many of the available safety devices.

Attitudes connected with reflective thinking follow:

1. Active curiosity

   Active curiosity toward socialized medicine can be shown if the pupils, after reading about the different plans that have been proposed for solving our medical service problems, desire to investigate further the adequacy of our own local medical services. A willingness to spend time outside of school visiting hospitals, clinics, and medical practitioners with this problem in mind would be an example of active curiosity in this regard.
2. Intellectual caution

   Intellectual caution would be shown if the student were unwilling to accept any of the proposals for bettering the medical service in this country until he had had an opportunity to read about and discuss each of the plans that have been proposed, and had considered the purpose and interests of each group that had proposed the plan. The questioning of authority and the method of investigation of each of the groups are further evidence of intellectual caution.
3. Trying out different points of view toward a problem

   This attitude is developed in such studies as those that were made of the methods of garbage collection and disposal used in Madison.

Sanitary precautions, frequency of service, extent of service, etc. were all compared with the methods of garbage disposal quite different from the one in actual operation.

4. Tendency to see a problem through to its conclusion

Insistence on the part of the teacher that the pupil must secure sufficient facts from his investigation to enable him to prepare a good report, and to enable him to reach some conclusions, often results in the pupil having to make several visits, arrange for interviews, and read several sources. This is time consuming, but the reward for the pupil comes when he realizes that he has followed his problem through and has been able to reach either tentative or definite conclusions.

5. Tolerance of new ideas and suggestions

Readiness to change his preconceived views on many of the medical and sanitation problems of the community is an indication of the student's tolerance of new ideas and suggestions.

D. *Self-direction.* Ample opportunity for the pupil to plan his own methods of attack is offered by the wide range of materials presented in the unit. He is made responsible for obtaining the information necessary to solve his problem. He is released from the immediate environment of the school so that he may use whatever sources he feels will contribute to the solution of his problems. The community then becomes his laboratory.

VII. *Understandings to Which This Study May Contribute*

One major effect of the Committee's report upon the development of this unit is seen in the list of generalizations and inquiries that follows. These were all taken from the report or suggested by it and are used to suggest subject-matter to which students might be directed. No one student can be expected to make much progress in the understanding of all of them; but all students make some progress in the understanding of many of them.

A. *Effect of the community upon the individual*

1. Physiographic and climatic factors in the natural environment have important effects on the social-civic life of people.
2. An individual continuously interacts with his surroundings.
3. Human advancement has depended largely upon better understanding and better control of the material and living environment.
4. The environment is constantly changing, necessitating changing adaptations to it.
5. Other institutions in society have taken over certain functions which originally belonged to the family.

6. An individual may obtain aid in his health problems from many public and private agencies.

7. Many of the scientific resources for protecting people against health hazards and for insuring various necessities have to be managed through the coöperation of many individuals, or through central or public agencies.

8. The efforts of trained specialists in medicine, engineering, chemistry, electricity, geology, and so on, are most useful when applied in coöperation with the efforts of other specialists and institutions.

9. Both for the sake of economy in utilizing limited resources in materials and personnel, and for the sake of efficiency in utilizing many varieties of skill, knowledge, and talent, it becomes necessary to organize as social, several forms of activities that were formerly carried on by individuals on their own initiative and responsibility, such as education, medicine, sanitation, and various forms of research.

10. The accumulation of earlier knowledge and experience of the whole race through libraries, museums, universities, laboratories, and other institutions is an important factor in making scientific research possible.

11. Specializations in knowledge and skill remove the individual from contact with raw materials, processes, and sources of information outside his own speciality, so that he cannot protect himself alone against adulterations, quackeries, and other misrepresentations regarding various necessary supplies and services.

12. The prevention of various kinds of sickness can be best brought about through community efforts.

a. Safe water supply is more economically and more surely obtained on a large scale, as the community increases in size.

b. The disposal of household and body wastes cannot be left to individuals except in rural regions.

c. Vaccination and inoculation against specific diseases are most economical and most effective if applied on a large scale.

d. Venereal diseases are most effectively controlled and cured through community clinics and regulations.

13. Scientific knowledge that bears upon health and sickness is derived from researches carried on by many kinds of scientists in different parts of the world, and coördinated for different purposes.

a. Problems of health and disease are studied by chemical, physical, electrical, and bacteriological methods in laboratories, as well as by the observation of sick people in hospitals and clinics.

b. Important medical and hygienic discoveries are freely and promptly made known to physicians and other health workers through publication in journals in all languages.

c. Important knowledge from various sources sometimes enables physicians, nurses, and other health workers in all parts of the world to improve their methods of dealing with sick people or of preventing sickness; for example, iodine, vitamins.

d. Some important discoveries can be applied only after the elaboration of complex systems for the production and distribution of various appliances, drugs, or other preparations; for example, U. V. lamps, arsphenamin, insulin.

14. Because of man's interdependence, a knowledge and control of our epidemic diseases is of extreme importance in the modern world.

B. *Effect of the individual upon the community*

1. Cultural advances arise from the interaction of people living together in large numbers.

2. Bringing large numbers of people closer together raises numerous community problems of sanitation, policing, housing, transportation, recreation, and human relations.

3. Variance is a common property of populations and is itself in this sense normal (normality of variation).

4. As population becomes denser, the uncontrolled individual use of soil, waters, and other natural resources may lead to undesirable consequences for others or for the whole community.

5. A sick person is a possible source of danger to others.

6. A sick person is a burden to others.

a. A worker who is incapacitated is for the time being, and by so much, reducing the total social product, while continuing to consume.

b. Any person who is sick is a source of attention, extra service, and other expenses.

c. Any person who is sick is a source of worry or suffering to others who care about him.

C. *Effect of science upon the individual*

1. The control of infection depends on knowledge of how the disease is spread, and of preventive and available therapeutic measures.

2. Many diseases are more easily treated if diagnosis is made early and competently.

3. Preventive medicine has been and is more effective in reducing morbidity and death rates than therapeutic medicine.

4. Medical science has found means to eliminate or minimize many of the dangers from "diseases of childhood."

5. Training in science is the basis of preparation for many vocations.

6. For which of our pressing social problems is the scientific method important in finding solutions?

7. Are there some problems in the solution of which the scientific method is useless? Wrong? Negligible?

D. *Effect of science upon the community*

1. Most of the significant ideas in modern science have come down to us through Greek and Arabic science, and through medieval sci-

ence, religion, philosophy, art, technology, and economic institutions.

2. During the last thousand years the material basis and the cultural forms of western civilization have been profoundly modified by the development of the machine.

a. Man's moral ideas and practices have been influenced by and have influenced technical inventions and processes.

3. Scientific techniques applied in production, transportation and communication, have influenced our standard and tempo of living.

4. Man's interdependence has created many problems, in whose solution scientific methods and information may play an important part.

5. Because of the large scope of certain human problems, the organization of international scientific effort is often required for their solution.

6. Difficulties created by the size of large cities are often met by applied science.

7. Vital statistics and hospital records supply necessary information for the development of community hygiene programs.

a. The isolated experience of individuals with sickness, food, and other matters that influence health cannot readily be made of value to others.

b. Mass statistics enable us to find out how various conditions, practices, or measures influence the health of people.

8. Scientific research is a prime essential to the material progress and welfare of a people.

9. Through science, men have found the means for insuring people's health, and for protecting concentrated populations against epidemic diseases.

10. Are scientists under obligation to interpret to society the findings of science both as to content and as to implications?

VIII. *Evaluation*

Tests have been constructed to evaluate the degree of attainment of some of the objectives we have set down for this unit. Two samples by the author follow, for the aspects of reflective thinking called "Application of Principles," and "Interpretation of Data." Further examples (including "nature of proof," scales of belief with respect to community hygiene and public medicine, skill in interviewing, knowledge of laboratory practices) developed for use in this same unit will be found in "Materials Prepared by Participants in the Science Group" (pages 101, 133, 135, 193, 199, 208, 218, 219) at the Summer Workshop of the Progressive Education As-

sociation, Evaluation in the Eight Year Study, University of Chicago, 1937. (Originally published at The Ohio State University.)

Are You Learning to Make Reasonable Interpretations of Data?

Problem 1.

The cost of the care of sickness has been found to be distributed between various agencies in the following manner:

Patients' fees	79 per cent
Government	15 per cent
Philanthropy	5 per cent
Industry	2 per cent

The total cost of sickness borne by families may be classified in the following way:

10 per cent of the families bear 41 per cent of the costs
32 per cent of the families bear 41 per cent of the costs
58 per cent of the families bear 18 per cent of the costs

The following table illustrates the relation between the incomes of various income groups and the amount of care they receive:

Income of Family	*Percentage of Family Who Received No Medical, Dental, or Optical Care*
Under $1,200	47%
$1,200 to $2,000	42%
$2,000 to $3,000	37%
$3,000 to $5,000	33%
$5,000 to $10,000	24%
$10,000 and over	14%
All incomes	38%

Part A. Read each of the following statements and indicate in the columns to the right (after carefully considering the data presented) whether you believe:

(1) The data alone justify the statement.
(2) The data suggest that the statement is probably true.
(3) The data are insufficient to make a decision concerning the statement.
(4) The data suggest that the statement is probably false.
(5) The data alone contradict the statement.

Statements	*Part A*					*Part B*
	(1)	(2)	(3)	(4)	(5)	
a. Some families have few or no cases of expensive illness						*a.*
b. People whose incomes are $10,000 or more bear most of the cost of medical care						*b.*
c. Seventy-three per cent of the people on the average bear 82 per cent of illness costs						*c.*
d. The expenditures for medical care by the lowest income group (less than $1,200) are higher in proportion to their income than those in the highest income group (over $10,000)						*d.*
e. Only 2 per cent of the cases of illness result from hazards in industry						*e.*
f. For the care of illness individuals pay approximately four times as much as do the government, philanthropy, and industry combined						*f.*
g. Long drawn-out cases of illness result in an uneven distribution of costs per family						*g.*
h. Approximately six-tenths (58 per cent) of the total number of families pay $60 or less per year for medical care						*h.*
i. People whose incomes are less than $2,000 per year do not receive adequate medical services						*i.*
j. Philanthropic support of illness is contributed to mostly by people whose incomes are $10,000 or over						*j.*
k. Families whose incomes are less than $2,000 are healthier than those whose incomes are over $5,000						*k.*
l. Taxes from people whose incomes are $5,000 or over contribute most to the governmental support of the cost of illness						*l.*

Part B. Can you identify the evidence which you need to be more sure of conclusions? In order to be more sure of some of the statements of Part A you may desire some further information. If you have marked any of those statements as "probably true," "probably false," or "insufficient evidence," go back to them, and determine what additional evidence you would need in order to make those statements more cer-

tainly true or more certainly false. Some of the kinds of evidence are given in the following list as questions concerning which you would want more information. Place the number of the factor or factors, concerning which you want more information, in the blank space corresponding to the statements of Part A.

1. What is the total amount of money spent for medical care?
2. What are the relative amounts paid per physician call by the various income groups?
3. What are the various causes of illness (sickness and accident), and how often do they occur?
4. How many cases of illness out of the total number are of relatively short duration?
5. How many families out of the total number in each income group need medical care but do not receive it?
6. How is the need of medical care distributed between the various income groups?
7. How much money is collected in the form of taxes by the government from each of the various income groups?
8. What is the average expenditure per income group for medical services?
9. How much does each income group contribute to the philanthropic support of illness?
10. Are most physicians' incomes greater or less than $5,000?
11. What percentage of the total number of families bears most of the cost of illness?
12. What is the number of physicians' calls which the members of the families of each income group receive?

Are You Learning to Recognize Examples of Generalizations?

From your work in this course you have had the opportunity to summarize many of your experiences in terms of generalizations. Four of these generalizations are listed below as A, B, C, and D.

A. Public hygiene is mainly useful in prohibiting acute infectious diseases.
B. Difficulties created by the size of large cities are often met by applied science.
C. Institutions and patterns tend to remain fixed as the conditions which created them change.
D. Individual hygiene is mainly concerned with the prevention of chronic diseases.

The following statements may or may not represent illustrations of these generalizations. In the appropriate columns to the left check those which you believe illustrate these generalizations.

A	B	C	D	*Statements*
				a. Smallpox today is relatively rare.
				b. Most people today are buried in cemeteries.
				c. Many people ride on subways.
				d. Children work in factories.
				e. Millions of dollars are spent each year for patent medicines.
				f. Very many cases of syphilis are present in the United States.
				g. The sick child is sent home from school.
				h. Large milk trucks and trailers are often observed on the road.
				i. A person doesn't worry about the water he drinks from a faucet.
				j. Most people go to a family physician for all their ailments.
				k. Many cases of abortion at the hands of quacks result in death for many women.
				l. Evolution is not taught in many schools.
				m. Poor-houses still exist in some communities.
				n. Free medical clinics are maintained in most larger cities.
				o. Heart disease is becoming more prevalent.
				p. Tuberculosis is rapidly becoming less prevalent.
				q. Chiropractors are licensed to practise in all states.
				r. Antivivisectionists are very active in some cities.
				s. The Federal Food and Drug Act does not protect the public against many of the modern proprietary medicines.
				t. Faith healing is still practised by many people.
				u. Much of the goitre in the "goitre belts" is being prevented by the use of iodized salt.
				v. Many drugs are still used even though they have been shown to be of little or no value.
				w. Many eye disorders can be traced to improper lighting.
				x. Many children have poor health because of inadequate diets on the part of the nursing mother.
				y. Many people die from carbon monoxide poisoning each year.
				z. Fumigation with sulphur candles is sometimes used after an infectious disease.
				aa. Raw milk is sold in most communities.
				bb. Many public buildings are poorly ventilated.
				cc. Many people believe that a child may be "marked" by the mother experiencing a great emotional strain.

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IV. A SOURCE UNIT IN GENETICS

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Introductory note by the Committee. This Source Unit in Genetics is included in the report to provide a concrete illustration of the "source unit technique" of curriculum construction. A unit of this type [1] attempts (1) to explore an area of human knowledge, in this case the area of genetics, for its potential contribution to the objectives of general education, and (2) to present the results of this exploration in a form directly helpful to the teacher.

In its original form this Source Unit in Genetics was prepared by Mrs. Diederich for the Bureau of Educational Research in Science, Teachers College, Columbia University. It was edited by Dr. Anita D. Laton, with the assistance of other members of the Bureau staff, and published in mimeographed form in August, 1937. Grateful acknowledgment is made to Professor S. R. Powers, Director of the Bureau of Educational Research in Science, for permission to incorporate a large part of the original material in this report. The original report is copyrighted by Teachers College, all rights reserved. The following presentation of the unit, however, represents an outgrowth of its author's attempt to apply the philosophy of the report to her own classroom practice in the seventh, tenth, and twelfth grades of the Horace Mann School. During the past year she revised these materials further for inclusion in this report.

[1] Another type of source unit might explore the various ways of meeting one particular adolescent need or helping to develop a particular personal quality, or solving a given problem which cuts across many "subjects." See Chapter X.

Introductory note by the author

As the name "source unit" indicates, this unit is intended to be used, by the teacher, purely as a source from which he may select whatever is appropriate to his purposes, supplementing the selected material as he sees fit.[2] What materials are selected and how they are organized for classroom use will depend on the needs and interests of the particular group of students with whom the teacher is working. He may draw upon the source unit again in an entirely different way when dealing with children of another age and background. For example, he might utilize materials from this genetics unit while working in the science laboratory with a seventh-grade group on the topic of growth and reproduction; a tenth grade might be engaged in a unit specifically on genetics; while the "core program" of a twelfth grade might give rise through a discussion of the Hitler regime to a lively consideration of the implications of our current knowledge of genetics for the problem of "race." It should be possible to use a source unit such as this not only as an aid in planning a more or less protracted unit of work, requiring from two weeks to two months, but also as a source for one or two student experiences to enrich at pertinent points a unit whose major theme is not genetics.

Thus, there is a fairly wide range of situations throughout the secondary school in science classes and elsewhere when material from the field of genetics is appropriate and desirable, whether as "main course," "side dish," or only "condiment" in the educational meal of a particular student group at a given moment. To facilitate, if possible, such flexibility in its use, this source unit has been organized as follows:

I. *A Source List of Objectives:* To what objectives of general education can the study of genetics make effective contributions? Analysis in terms of "Basic Aspects of Living," "Adolescent Needs," and "Desirable Characteristics of Personality."

II. *A Source List of Generalizations* from the field of genetics, each followed by a discussion of its scope and significance. This section sketches for the *teacher,* not for the student, "Our Knowledge of Genetics and Its Implications."

III. *A Source List of Some Ways of Introducing a Unit* in genetics:

[2] The author wishes to thank Lawrence H. Snyder, Cuthbert Daniel, Clark Horton, and Charles Boye for their interest and helpful suggestions.

a list of specific student experiences that can be used as approaches to work in genetics.

IV. *A Source List of Experiences for Students in the Light of Objectives Listed:* This list cannot be exhaustive, but it has been made as extensive and suggestive as possible. No teaching sequence is indicated here; the experiences are simply grouped and discussed under four headings:

A. Breeding Experiments
B. Demonstration and Classroom Experiments
C. Projects for Home and Laboratory
D. Topics for Reading, Discussion, Reports, Debates

V. *Evaluation of Student Progress Toward Objectives:* How do we measure to what extent we are realizing our stated objectives? Discussion and as many sample techniques as space permits.

VI. *Bibliography*—for student, for teacher; classified and annotated.

I. OBJECTIVES

To what objectives of general education can the study of genetics make effective contribution? In other words: *What implications has genetics for the basic aspects of living? What, if any, adolescent needs can it help in meeting? Does it afford any particularly good tools with which to develop one or more desirable characteristics of personality?*

These are the criteria which the philosophy of the report gives us for deciding what subject-matter and methods shall be used, and what excluded, in our teaching. Hence the first step in making this source unit was to explore the area of genetics with these questions in mind. The following pages represent one teacher's attempt at answering these questions. The analysis takes each of the basic aspects of living in turn, and each of the desirable characteristics of personality, to see in what ways the area of genetics might be utilized to special advantage. The items listed below overlap, necessarily, and some, of course, are of greater importance than others. The particular objectives which would be especially stressed at any given time would vary according to the needs and interests of each student group.

To interpret this unit correctly the reader should bear constantly in mind that "to teach genetics" is not the objective of the unit. Meeting the needs of students, helping students to cope with the particular problems of contemporary life and to develop desirable

characteristics of personality are the prime concerns of every teacher.

Analysis

I. What *adolescent needs* can the study of genetics help in meeting? What implication has genetics for the basic aspects of living?

Possible contributions

1. In the *Area of Personal Living*
   - 1.1 Helping to meet the *Need for a World Picture*
     - 1.11 Understanding the basic mechanisms of heredity and their implications as to the nature of man and of the biological world
     - 1.12 Understanding the rôles of heredity and environment, and the inseparable connection between them which renders meaningless questions of relative importance of heredity and environment
     - 1.13 Understanding the contribution of genetics to our knowledge of evolution; the light that it sheds on how evolution came about in the past and how it continues in the present and future
     - 1.14 Appreciation of the continuity of the germ plasm and the oneness of all life; also the universality of variation
     - 1.15 Understanding the meaning of "race"
     - 1.16 Increased understanding that knowledge develops, truth is partial, and authorities shift
   - 1.2 Helping to meet the *Needs for Personal Interests and Esthetic Satisfactions*

     Comment: There seem to be two pitfalls to avoid here:

     a. Assuming that material which seems important and interesting to us is *ipso facto* equally important and interesting to our students

     b. Assuming that all students will find personal interests and esthetic satisfactions in the same kinds of experiences

     Bearing these points in mind, however, it still seems reasonable to suppose that the following will have value for some students at least:

     - 1.21 Interests associated with the care and breeding of animals and plants
     - 1.22 Interests expressed through minor personal investigations, experiments, projects, and further reading (See Chapter III, "Suggestions to the Teacher" on *Personal Interests* for some of the forms which these interests may take.)
     - 1.23 Interest in the "world picture" presented by science, especially in the area of genetics, which may include:
       - 1.231 Intellectual and emotional stimulation ("kick")

arising out of the discovery (new to them) of a body of fundamental facts and principles which help in explaining and controlling familiar things

1.232 Increased appreciation of the progress of science in the conquest of the unknown through the utilization of scientific method

1.3 Helping to meet the *Need for Self-Assurance*

1.31 Understanding the rôle of heredity in one's own development

1.32 Correction of misleading superstitions (There are also superstitions in other areas which should be corrected.)

1.33 Understanding better one's own assets and liabilities and what can be done about both; self-tolerance

1.34 Functioning understanding of normal variability

1.35 Better understanding of the reproductive process

Comment: The extent to which the student will form constructive attitudes because of new information will depend on the quality of the teacher's guidance. Certainly such attitudes do not follow automatically from the mere acquisition of knowledge, however pertinent.

2. In the *Area of Immediate Personal-Social Relationships*

2.1 Helping to Meet the *Need for Successful Relationships with Other People*

2.11 Increased understanding of the forces which shape other individuals, including the influence of friends, family, and others with whom the adolescent has contact

2.12 Increased tolerance of the wide variation in people; more intelligent attitude toward "praise and blame"

2.13 More intelligent choice of a husband or wife (awareness of considerations that are valid from the standpoint of present genetic knowledge and recognition that certain worries are groundless)

3. In the *Area of Social-Civic Relationships*

3.1 Helping to develop an *Adequate Social Philosophy*

3.11 Acquisition of a foundation of biological facts (where they are known) which will form a sound basis for one's interpretation of such problems as:
Race betterment
Population, immigration
Crime
Political problems of race
Social problems of race
War

3.12 Practice in intelligent use of this basis of fact—and recognition of its limitations—in discussions, etc.

3.13 Practice in intelligent interpretation of statistical data and conclusions found in the press, in books, in adver-

tising, in political campaigns; development of a critical attitude toward slipshod use of such data

3.14 Development of constructive social attitudes based on better understanding of some of the underlying facts, for example:

3.141 Better understanding of the forces which shape people

3.142 Increased tolerance of the wide variation in people

3.143 Increased sense of responsibility toward other people as a group, especially those underprivileged by heredity and / or environment

4. In the *Area of Economic Relationships*

4.1 Helping to develop a *Constructive Economic Philosophy*

4.11 Appreciation of the significance of genetics for agriculture—past, present, and future

4.12 Some understanding of the economic implications of scientific breeding applied to agriculture on a large scale

4.13 Increased insight on the problem: Should the world be an economic unit?

II. Which *educational values* can the study of genetics help to develop?

1. *Developing Reflective Thinking*

1.1 Increased ability to interpret simple statistical data

1.11 Understanding and correct use of such concepts as:

1.111 General unreliability of conclusions based on small samples

1.112 Predictions accurate for large groups, but useless when applied to a given individual

1.113 Normal curve of frequency distribution (acquaintance with basic features, rather than terminology); significance of "normal variability"

1.114 Values and limitation of interpolation and extrapolation

1.115 Effect of larger and larger numbers on accuracy of conclusions

1.116 Difference between "mathematical" conclusions and statistical conclusions

1.117 Difference between "possible" and "probable"

1.12 Ability to recognize common statistical fallacies related to the above concepts in the reasoning employed in advertising, in the press, in books, in political campaigns, by one's associates

1.2 Increased ability to make use of reflective thinking in general—Work in genetics has a contribution to make to the abilities and attitudes needed for reflective thinking with particularly good opportunities for

1.21 Distinguishing fact from assumption, and fact from theory

1.22 Drawing inferences from data
1.23 Applying principles (with practice in transfer to situations involving social and economic implications)
1.24 Testing hypotheses in actual situations
1.25 Increased practice in and understanding of the experimental method of science
1.26 Evaluation of authority
1.27 Development of intellectual caution, coupled with confidence in the scientific method

2. *Developing Tolerance*
   2.1 Tolerance of variations in other people; less smugness in allotting praise and blame
   2.2 Self-tolerance—understanding of normal variability as applied to oneself
   2.3 Honest attempt at sympathetic appraisal of other races—socially and politically
   2.4 Honest attempt at sympathetic appraisal of other points of view, for example, social and economic theories of race betterment
3. *Developing Social Sensitivity*
   3.1 Appreciation of the kinship of the human race
   3.2 Sensitivity to the effects of one's acts on other people, as, for example, as a transmitter of hereditary characters; as a potential influence for bettering the human environment
   3.3 Willingness to take measures that run counter to one's immediate comfort or to that of the group with which one is immediately identified, for the sake of the broader social good (This sort of attitude may be brought about through discussions of eugenics and euthenics.)
   3.4 Willingness to look upon social maladjustments as problems to be solved by the application of intelligence, for example: Development of intelligent reasons for one's beliefs about race betterment through eugenics, or through bettered environment
4. *Developing Esthetic Appreciations*
   See discussion above of Personal Interests and Esthetic Satisfaction, also footnote below.
5. *Developing Coöperativeness, Self-Direction, Creativeness* [3]
   In the development of these characteristics the teaching of genet-

[3] To save space the analysis in this unit has been restricted to those aspects of various objectives where genetics has particularly valuable or unique contributions to make. There are also many objectives of education, particularly those involving desirable characteristics of personality, which can be achieved equally well through the use of many different kinds of subject-matter, because the essential element in these cases is the teacher's methods rather than any unique subject-matter.

ics has no unique contributions to make. Teaching methods, no matter what the subject-matter, are most important in the development of these characteristics.

The value of having thus gone through a detailed analysis of the larger objectives consists in the increased ability one develops to recognize in class work opportunities for working toward a particular objective and for evaluating student progress. However, once a detailed analysis of objectives has been made, it becomes imperative for most of us to single out the few most important objectives, and to work steadily toward them.

To a different extent with each different student group, the following may be considered *Important Special Objectives of a Unit in Genetics:*

I. To enrich the biological aspects of the "world picture"
II. To increase understanding of, and ability to use, reflective thinking, especially in interpreting simple statistical data, and in using, and appreciating, the experimental method of science (applied to science and transferred to other fields)
III. To provide a factual basis for thinking about many problems of social and economic significance; to encourage constructive attitudes and the use of scientific thinking in these problems
IV. To increase the student's understanding of himself and others, and encourage constructive personal attitudes
V. To increase personal interests and provide esthetic satisfactions, wherever possible

II. PRESENT-DAY KNOWLEDGE OF GENETICS AND ITS IMPLICATIONS

This section does not presume to be a "text" for the teacher; it is simply an attempt to sketch in a way that may be helpful to some teachers, the broad outlines of present-day knowledge regarding genetics and its implications. The discussion presupposes an elementary knowledge of genetics and therefore elaborates only on some of the implications (as we see them). The area of genetics is summarized in a few broad "generalizations" and each generalization is followed by some discussion of its scope and significance. (Such discussions are not a necessary attribute of a "source unit," but in some cases they are useful.) Needless to say neither the generalizations nor the discussion of them as given here are intended

for direct presentation to students. Students will attain some level of understanding of whatever generalizations the teacher feels are important for them, as *outcomes* of their experiences in studying genetics. Possibly they may even summarize their understandings from time to time as general conclusions, but certainly the teacher should never give them the statements as phrased here.[4]

Through Generation after Generation Living Things Tend to Resemble their Parents and yet to Differ from Them

1. *Every expressed character in an individual is the product of the interaction of genetic and environmental factors.*

Human beings have always been interested in finding out to what extent the characteristics of their forefathers are passed on, generation after generation; to what extent human beings are the product of their own experiences and masters of their own fates. "Nature or nurture," "heredity or environment," are the modern terms in which we state part of the problem. *Perhaps the most important contribution made by the modern study of genetics is a clarification of this problem to the extent that it is now recognized that no trait of an individual, be it a man, a dog, a butterfly, or a tree, is uniquely the product of either heredity or environment.* Certain bits of living stuff, the germ cells, produced by adults, become the new individual. These carry substances which set limits within which the new individual can develop *if,* but only if, an environment exists conducive to that development. Potential musical ability may never be recognized if opportunities for its expression are lacking. A stunted tree growing on rocky ground might well have been a giant if planted upon rich soil. It is probable that every living thing, ourselves included, has potentialities in one trait or another which have not reached full development for lack of the appropriate environmental stimuli. The problem has changed from the theoretical one of heredity *or* environment to the more indefinite but more hopeful one of finding for individuals the environmental stimuli which will encourage development of their finest potentialities. This fact should inspire the average person with new courage to face life in spite of failures, and with increased tolerance and understanding of other people. For those responsible for the care of children—as are all of us in the rôles of parents, relatives, or tax-payers—it should mean increased interest in providing good living conditions for children and rich educational opportunities, in order that potentialities

[4] The discussion of these generalizations is largely the contribution of Dr. Joseph Schwab.

which they possess may have opportunity to develop for the increased happiness and efficiency of their own lives and for their contribution to the welfare of others. It should lead to greater understanding of law-breakers, a mitigation of the too-universal feeling of vindictive resentment against them, more intelligent supervision of the individuals themselves, and a direction of attention to the conditions in our communities which facilitate the development of anti-social attitudes and behavior. It should also bring about better understanding of the feeble-minded and the insane, alleviation of unreasonable fears of them and aversion for them, and more intelligent attention to their needs, both in and out of institutions. The hereditary make-up of every individual is determined at the moment of conception and, therefore, the responsibility of each individual to those about him is that of recognizing limitations where these exist, discovering valuable potentialites, and providing environments for himself and for others, that will, as far as possible, permit expression of potentialities in reasonable situations.

As was suggested above, the once common question, "Is it due to heredity or to environment?" has become meaningless. There is no such thing as heredity separated from environment. All hereditary characteristics require an environment in which to express themselves. We can discuss the possible "hereditary" variation only if we know what the environment is; in a different environment the expression of this "hereditary" variation is often different; and vice versa. (See under *Suggested Experiences,* "The Fallacy of Heredity vs. Environment"; also discussion under 7*c* in this section.)

The study of genetics should also be an aid in the development of precise ideas with regard to such commonly misused descriptive terms as *hereditary* and *congenital. Hereditary* is a precise term, referring to traits the factors of which are carried in the germ cells; *congenital* is a loose term referring to traits present at birth which may be hereditary in origin or may be the result of environmental factors acting prenatally. Some of our misconceptions regarding hereditary traits arise in the confusion of the two. Communicable diseases, for example, are not hereditary, although some of them, such as syphilis and tuberculosis, may be "caught" from the mother and be present at birth. (It should be noted, however, that although the communicable disease iself is not heritable, for some diseases, such as tuberculosis, the amount of normal body resistance to infection is influenced by heredity.) Birth marks, also, fall into the class of traits which are not considered hereditary. They are usually due to adhesions of the embryo to its surrounding membranes, to faulty metabolism, or to anomalies in development. They are not due, of course, to a mother's thoughts or feelings during pregnancy. Properly speaking, they should be considered in a study of embryology, not heredity. The reason for referring to them here is that they are so closely associated in the minds of some people with that mysterious thing, "heredity."

2. *Variation is a universal phenomenon among living things.*

This statement is really a corollary to the first statement, but it is so important that it requires special mention. That living things vary is common knowledge; realization that there is some variation in every observable characteristic is somewhat less common. Children need to recognize that a given variation may be due chiefly to genetic differences, for example, the color of their eyes where there is no significant variation in environment, or it may be due chiefly to environmental differences, as in differences produced in genetically "identical" twins reared under different conditions. (See 2*g*.) They should also realize that genetic and environmental differences usually exert a combined influence, for example, in one's height and weight.

Another aspect of variation is the recognition of qualitative variation, for example, blue eyes compared with brown eyes, and quantitative or "continuous" variation as exemplified by the range in height of a large group of individuals. There is, of course, no sharp line of demarcation between the two kinds of variation. There is a range of eye color from gray through varying shades and intensities of blue; there is a range of browns from hazel to dark brown and black; in the eyes of a few people specks of brown and blue pigment are both evident.

For adolescents certain realizations about "continuous variation" are especially important. If students record the heights of their class members, it will be evident that the group shows a tendency to have more members of intermediate height than extremely short or tall ones (central tendency). The frequencies, if plotted, give the familiar bell-shaped curve (approximately the curve of normal distribution). The pupils should be given to understand clearly that the "midpoint" of this distribution, the *average,* is only a convenient way of describing the group. Actually very few individuals are average, and "normal" is not the same as "average." Normal refers to a range, not a point, and may in some cases include the entire distribution. To feel that he is "normal" is a matter of great emotional importance to the adolescent. (See Chapter III of this report, section on self-assurance: "Many emotional conflicts and feelings of inadequacy or shame and fear are created or enhanced by the failure to realize what behavior and what physical and physiological characteristics are normal in human beings, and in adolescent development in particular.") Thus the teacher can help many adolescents to see that variation is normal, that "normal" does not mean "average," and to find out what range of variation in various physical and psychological characteristics is considered normal. Some of this can be done in a unit in genetics, some of it can be done in other connections.

3. *The basic mechanisms of heredity have been and are being deduced from the statistical results of breeding experiments, supplemented*

more recently by cytological study which has demonstrated in the chromosomes a physical basis for interpreting these results.

It is important for every one to understand something of the methods by which knowledge of heredity has been gained. Such knowledge should do much to guard against uncritical acceptance of preposterous claims made in the name of "scientific genetics"; at the same time it should increase one's trust in carefully determined knowledge. It should, also, give rise to some understanding of the nature of knowledge itself, a question which is by no means so simple as most of us believe it to be.

a. Thousands of characters in lower animals and plants, and dozens in men, are known to follow the same statistical laws.

In removing the aura of mystery which surrounds the unknown, it is important to realize that the "laws" of heredity are not arrived at mystically and are not formulated in abstract terms to fit all cases, but are the outgrowth of experimental study of generations of plants and animals. For students at any level, probably the best approach is to follow through, by first-hand experience, some of the experiments carried out by workers in genetics—coat color in mice or rabbits, shape of wings in fruit flies, or any other of the thousands of traits studied in plants and lower animals. The method of procedure is simply to find simple traits for study, to breed the animals and then count the traits in question in family after family until the numbers become so large that the effect of chance can be minimized and simple statistical relationships between generations can be expressed. This can be followed with a little work showing how laborious was the collection of information with regard to a very few human traits and how this information led to the discovery that these traits follow, in general, the same statistical relationships as those found in other living things.

The study of genetics offers particularly good opportunities to help students grasp a few elementary statistical concepts that are important in everyday life. Some of these are: that generalizations based on small samples are usually unreliable; that "probable" and "possible" are not synonyms; that some kinds of predictions can be made accurately for a group, but not for a given individual, etc.

b. These statistical results are explainable in terms of the separation of hypothetical paired factors during germ-cell formation and the reformation of the pairs of factors as a result of fertilization.

The statistical results of genetic studies represent the actual examination and counting of traits in large numbers of separate individuals. To explain them a theory has been formulated with regard to the factors carried by germ cells and the establishment of newly combined pairs of factors at fertilization. These hypothetical factors have been

given the name of *genes,* a term so easy to employ that we use it constantly in our speaking and reading as if it represented things which could be seen and handled as easily and as readily as seeds or guinea pigs.[5] As a step in the development of scientific thinking students must be made to recognize clearly the difference between the facts on which a theory is based (in this case the observable traits in real plants and animals) and the theory, which is offered as a possible explanation of the facts. Even very young children can begin to learn the difference between facts and theories. This material offers excellent opportunities for such teaching which the alert teacher can use in other fields, for example: evidences of evolution and the evolutionary theory, behavior of matter and the atomic theory, wars and the causes of war, crime and the causes of crime, human behavior and explanations of it, the prediction of weather, the treatment of diseases down through the ages. The important thing for children to learn is that a good theory is one that fits all the known facts.

c. The visible behavior of chromosome segments during meiosis and fertilization corresponds with the behavior deduced from simple breeding data.

Chromosomes, when properly stained, are observable under the microscope. They break into segments, and these segments behave during meiosis and fertilization as you would expect them to behave, according to the theory concerning paired factors in genetic phenomena. Students who can use microscopes can actually see chromosomes at various stages of meiosis and can gain further practice in differentiating realities, in this case, chromosomal behavior, from theories. Older students can learn to appreciate that this corroboration of a theory by data gathered in quite another field from that of the original investigation strengthens the validity of that theory far more than do additional data in the same field. This idea may be extended into other fields. In science, evolution offers a good example of a common theory that is demonstrable through data collected from the fields of paleontology, embryology, comparative anatomy, ecology, and comparative physiology. In the field of behavior, neurological and endocrinological data substantiate observations made in psychology. An interested class may suggest other examples.

[5] Although it is not a distinction we shall ordinarily want to make with children, it is becoming increasingly important in genetic theory to correct the common assumption that a "gene" "produces" the visible character associated with it, that is, that one gene produces black fur in mice, while its allelomorph produces brown fur. The more accurate concept is of course that the whole gene-complex is concerned in the production of the black fur, and brown fur is due to a substitution in one element of this gene-pattern, namely, a change of one "gene." The English, in fact, use the more accurate term *gene-substitution* where we say *gene.*

d. In addition to providing an acceptable explanation for the simple aspects of heredity, the visible behavior of the chromosomes suggests additional, more complex, hereditary patterns, which are actually found in further breeding experiments.

For example, chromosomes, by their shape and number as well as by their behavior in dividing into segments, suggest that certain traits may frequently be associated in the same individual, that certain ones occur most commonly in one sex, and other modifications of simple hereditary patterns. Older students appreciate examples of data in one field that suggest phenomena to be looked for in another field.

e. Man fulfils the biological requirements for being subject to the same laws of heredity as other organisms.

Among these requirements are sexual reproduction, a chromosome mechanism which undergoes meiosis, physiological processes similar to those of other organisms, etc. Hence, it is a workable scientific hypothesis to assume that the same laws which apply to inheritance in plants and animals will also apply in man.

f. The inheritance of many characteristics of plants and animals, including man, is explained by the interaction of many hereditary factors, each segregating and recombining (during meiosis and fertilization) independently of the others.

Most of the complex characters of humans, such as height and intelligence, are products of the interaction of many hereditary factors. The very number of possible factors that can interact to determine the potential limits of height and intelligence, plus the complexity of the characters themselves (which in itself makes accurate measurement difficult), is responsible for the existing lack of dependable information concerning their specific mode of inheritance. However, experimental work with such traits as coat color in guinea pigs is yielding much valuable information concerning these complex traits. This insight should help students to be critical with regard to sweeping conclusions concerning inheritance of intelligence, character, and personality, without at the same time causing them to lose all belief in the hereditary nature of some, at least, of the factors involved.

g. Many "hereditary" factors are found to be partially or wholly "linked" with others rather than inherited independently.

In a good many experiments certain traits are found to occur most frequently in one sex, a phenomenon that can be explained by the fact that the determining factors are located in the "sex" chromosomes. Other traits very frequently occur together, as if the factors concerned lay close together in the same chromosome. In human beings, fair hair and blue eyes behave thus. Night blindness, color blindness, and haemo-

philia are "sex-linked" ("linkage" was spoken of earlier as one of the phenomena first drawn to our attention as being caused by the behavior of chromosomes). Because the "sex chromosomes" are not normally paired in both sexes the inheritance of traits which depend upon factors in the sex chromosomes, differs from the inheritance of characters which depend upon factors in other chromosomes. Daughters of color-blind fathers (but of normal mothers) will not, themselves, be color-blind, but half their sons probably will be. This accounts, in part, for the popular belief that certain traits "skip generations," appearing in maternal grandfather and sons, but not in the intervening daughter. Present knowledge of linkage in humans (except for sex linkage) is very inadequate.

h. Many "hereditary" characters are subject to non-genetic, that is, environmental, variation in expression.

Many examples are known of individuals with the same genetic make-up who show different characteristics when influenced by different environmental factors. Plants growing in the dark do not develop chlorophyll. Many of the traits of Drosophila vary with the temperatures at which development takes place. In human beings the differences between identical twins (identified as such) reared under different conditions has contributed much to the general understanding of genetic and non-genetic influences.

4. *Evolution is a process consisting largely of the chance formation of new hereditary factors (or new chromosome arrangements) and their loss or increase in frequency within a population.*

Interest in evolution has during the past decade or two been due in large part to evidences bearing out a theory of evolutionary change. Genetics gives us an explanation of the mechanism of these changes. New traits are produced through mutation and by the subsequent combinations and permutations of new genes so produced, also by new chromosome arrangements (non-disjunction, translocation, and ploidy). New traits produced by these combinations may then, either by chance or through natural selection, spread through a population until they become characteristic of the species, race, or variety, as a whole.

Again, the significance of this newer information lies largely in the clarification of our usually hazy ideas as to just how the characteristics (or traits) of groups may change from age to age. The fact that chance breeding plays so large a part in determining the frequency of a given gene in a population should be enough to do away with the idea that every characteristic of a race or species is present because it was "selected." This idea has greatly influenced recent thought regarding the conscious improvement of the human race.

To the adolescent there is a further significance in the contribution

of genetics to the theory of evolution, for it enables him to see "evolution" going on here and now (through observation of mutation and selective breeding) instead of confining him chiefly to evidence established in the dim past.

5. *The difference between one race and another is usually not a matter of the possession by one or another of certain unique characters.*

   a. *Races differ largely in terms of the relative frequency of genetic factors which are common to all of them.*
   b. *Because of the nature of the process of mutation and the operation of chance, most racial differences are trivial; the probability of socially significant differences between races is low, but it is not zero.*

Of the material to be found in the fields of genetics and evolution, that which applies to the problem of human races is among the most significant. Confusion of genuinely biological racial groups with national, political, religious, and language groups, plus sweeping conclusions concerning the "hereditary" nature of personality traits, plus false and misleading statements concerning differences between races have been used as rationalizations and justifications of many of the tragic personal and national antagonisms which beset the world today.

Possession of a common home land, speech, or belief cannot alone forge a group of individuals into a race. There must also be, for century upon century, a thorough interbreeding of the individuals comprising the national, language, or religious group combined with a rigid abstinence from outbreeding. No present-day group fulfils these two criteria. Class prejudices of all kinds prevent thorough interbreeding within nations, while outbreeding goes on at a tremendous pace—even between individuals of different major stocks. For instance, "pure" Negroes are becoming increasingly rare in the United States.

Even if the various races had abstained from outbreeding and were "pure," our present knowledge of human heredity and race formation provides no basis for the assumption that one race is superior to another in such socially significant traits as honesty, ambition, and intelligence. For these are traits which we cannot even measure accurately. Good scales for this purpose do not exist. Furthermore, on the basis of the inaccurate measurements which we do possess, we have been able to add nothing at all concerning the relative importance of heredity and environment in producing variability in such traits as honesty and ambition. Concerning intelligence, data from different sources are far from unanimous in their conclusions. Estimates of the rôle of heredity in determining intelligence range from 100 per cent to zero.

There is the further question of whether (granting for a moment

some finite amount of genetic determination of socially significant traits) such traits are likely to be distributed unequally among the various races. Such unequal distribution could take place in two ways —through the occurrence of positive mutations of genes for certain traits in one race but not in another, or through the failure of such genes to persist and multiply in one race or the other. The former is almost impossible. According to present-day knowledge of the mutation process (a knowledge which is now quite extensive) mutation of a particular gene or of the genes governing a particular character is not due to specific, related aspects of the environment. It is likely to occur at any time or in any place. However, the possibility that there may be racial differences in the persistence and multiplication of such genes is not so highly improbable. Just as chance or random sampling has played a part in the establishment of racial differences in the frequency of genes governing such trivial traits as skin color, hair texture, skull sutures, and nasal angle, so it *might* conceivably have played a part in establishing racial differences in intelligence. But it must be remembered that this is merely a probability. No data are yet extant which permit the conclusion that such a racial differentiation has or has not occurred.

Finally, it must be remembered that whatever racial differences exist apply only to the averages of the groups. They do not apply to individuals. Two individuals of a given race may differ more markedly in intelligence than the averages of two separate races. For races do not differ in that one race has a unique possession of traits which other races lack, but rather in that one race may possess a greater store of genes for a particular trait than does another race. Thus Negroes as a whole are not devoid of those genes which have a positive effect upon the height of the nasal bridge, nor do all whites possess the maximum number of such genes.

Such facts should help students to be critical of boasts of racial superiority, more tolerant of individuals of other races, and less prone to ascribe to such individuals all the characteristics of the race to which they belong. The need for greater racial tolerance is universal, although the particular prejudices which the teacher must combat will vary with his geographic location. The intolerance may take the form of personal objctions to playmates and work mates, or of group pressures such as residential zoning, limitation of educational facilities, and establishment of wage and employment standards.

6. *Knowledge of the mechanisms of heredity has made it possible to substitute system for trial and error, and dependable prediction for guess work in the production of new, more useful varieties of plants and animals.*

Domestication of plants and animals and improvement of stocks have gone on for ages. The best stock has been saved for breeding; the

best corn has been saved for seed without definite knowledge of the relationship between the appearance of parents and their behavior as sources of genetic factors. Often, pigs of great weight yielded runt offspring; matings of prize-winning dogs yielded litters of which one or more departed widely in appearance from that of the parents. Failure to distinguish between genetic and non-genetic traits and the use of appearance only as a measure of genetic make-up were the causes of such unexpected and unwanted results. As an example of the second type of mistake, bulls which have won blue ribbons in the show ring have been known to lower the average milk production of their daughters as compared with that of their dams, whereas certain bulls of inferior show ring standards have raised their daughters' average milk production. Modern plant and animal husbandry is based upon an understanding of genetic mechanisms. This makes it possible to attain regularly achievements which before occurred accidentally, for example, the "fixing" of mutant recessive traits by inbreeding in succeeding generations when they have been "lost" in the first generation; or the planning of desirable combinations of traits and purposive and economical breeding to achieve them.

The United States *Yearbooks of Agriculture* for 1936 and 1937 contain excellent summaries (forty or fifty pages in each volume) describing the progress man has made in the past and is now making in producing new and more useful varieties of plants and animals. Part of the importance of these achievements for man's present and future is obvious. The *Yearbooks* also point out,[6] however, that the average hen in the United States produces eighty eggs per year; yet there are flocks of well-bred birds which produce over two hundred eggs per bird per year. Similarly average butter-fat production is 165 pounds per cow per year; yet the herds surveyed for the *Yearbooks* averaged 450 pounds per cow per year. Thus the egg and milk production of the United States "could be greatly increased with no more hens and cows than farmers now have to feed and care for." [7] With the possibilities thus suggested, contrast the fact that even in 1929 not nearly enough milk and eggs were produced, some estimates say less than two-thirds of what was needed to give all our people enough of these foods for the best nutrition. This discrepancy between potential and actual food supply should challenge our older and more thoughtful students to inquire into its causes and possible remedies. The problem is, of course, not simple; such fundamental economic considerations as the distribution of income and the effect of increased production of goods and services in our society are involved.

7. *Success in the breeding of new and of more useful domesticated animals rests upon knowledge of the mode of the inheritance of*

[6] U. S. *Yearbook of Agriculture,* 1936, pp. 122–123. See bibliography.
[7] *Ibid.*

specific traits; a similar success with the human species must await similar knowledge concerning the socially significant traits of human beings.

a. Practical obstacles to the controlled breeding of large numbers of humans, such as social taboos and the duration of generations, plus the complexity of the socially significant traits of man, make it unlikely that such knowledge will be achieved in the near future.

The statement is often made or the fact implied that we could build the human beings of the future to any pattern we desired by applying the same kind of knowledge to human breeding as we do to that of plants and animals. Laying aside for the moment practical questions which would make such experimentation well-nigh impossible, two questions immediately arise: "What kind of human beings should be developed?" And "what are the genetic patterns of the traits considered to be desirable?" To neither of these two questions can an answer be given. Indeed, there is no basis for an answer to the first question, except in personal opinion. Would we like courageous men? We do not even know whether courage is an hereditary trait, much less how it might be inherited. Do we envisage the human race of the future as highly intelligent? But there are many aspects of intelligence, some perhaps more desirable than others. Certain aspects are undoubtedly hereditary, but the factors involved are so many and the patterns so complex that we would not know how to go about securing these desirable traits in any particular individual. Thus, practically all these traits which are socially desirable are impossible of definition and their occurrence cannot be predicted under even the best of experimental conditions. Proposals for improving the human stock by selective breeding should be reviewed critically, with these facts in mind.

Another point worth emphasizing is that the "hereditary nature" of an undesirable trait does not imply that artificial selection (via eugenics) is always the only or the most satisfactory method of controlling its expression. Certain African races show greater immunity to malaria than does the white race. This is probably due to centuries of natural selection in a malaria-infected region. But compare such natural protection with the artificial immunity to smallpox produced by vaccination. Control of the environment (via vaccination) is so satisfactory a method for the control of smallpox that control by eugenic measures (selective breeding for high natural immunity) is not worth serious consideration.

b. The mode of inheritance of a few rare negative traits is known, and these could gradually be eliminated by limitations or prohibitions of breeding.

Sterilization programs, marriage restrictions, and programs for limiting reproduction, where carried out, aim to remove from the popula-

tion some of these negative traits. Students at the upper levels should certainly be acquainted with the sterilization and marriage laws, where they exist, of their own and other states, and of other nations. They should know what these laws aim to accomplish, how many individuals are affected by them each year, and whether they are grounded in the best knowledge available in this field. Students should also evaluate our immigration laws for their effectiveness in adding desirable hereditary traits to our population and keeping undesirable ones out.

c. For the present, "improvement" of the human races is richly and immediately feasible through euthenics rather than through eugenics.

In considering populations as a whole we return to the issue of heredity versus environment which was discussed earlier. Modern knowledge of genetics emphasizes the fact that these factors are interrelated. The practical question is, "Which of the two is most readily controllable at the moment?" Despite the emphasis in recent years upon poorly thought-out or overtly false programs of eugenic betterment, programs of *environmental* betterment are far more likely to be successful at present. Opportunity has never been provided for the fullest development of the hereditary potentialities of most, if not all, of our population. Students may well concern themselves with practical ways of extending health and education programs as intelligently and as economically as possible toward the accomplishment of this purpose.

8. *Although research in human genetics should ultimately have great importance for eugenics, its greatest practical importance in the near future probably lies in the field of medicine, especially in the field of preventive medicine.*

At present with the aid of new statistical instruments (for example, gene-frequency analyses) and other techniques (for example, "twin analyses"), research workers in human genetics are trying to collect enough information about human inheritance to "map" the human chromosomes, in much the same way as the chromosomes of the fruit fly have been mapped. Such mapping (together with the fuller knowledge this implies as to the mode of inheritance of a large number of traits) will probably be of value in medical practice and research. Suppose, for example, that it is found that "linkage" exists between some characteristic observable at an early age and the susceptibility to a particular disease; namely, that owing to the genes concerned being located close together on the same chromosome the two characteristics will usually both appear sometime in the individual's life or else neither will ever appear. The doctor, in such a case, has a double advantage. Upon observing the key characteristic, he expects the disease to develop; therefore he looks for the obscure first symptoms and makes

an earlier diagnosis which increases the chances of a cure. Moreover, he can predict that certain individuals are especially likely to contract the disease years before that event and so can concentrate more effectively on preventing (and on learning how to prevent) their contracting that disease. This example illustrates only two of the possible applications of genetic knowledge in the field of medicine.

In conclusion we should note that in all areas of genetics, basic research—the research done without reference to immediate "practical application"—has the same importance and claim upon our respect and support as does basic research in other areas of science.

III. SOME WAYS OF INTRODUCING A UNIT IN GENETICS

What Contact Have Children Probably Had with "Genetics" before Actually Studying It?

At almost every age children have some knowledge of genetics, if only such obvious knowledge as that offspring resemble their parents, kittens grow into cats, puppies into dogs, children into men and women. They are likely to know something about mongrel dogs or to be aware of the fact that pedigreed animals are expensive and well thought of, and they may even have pets whose ancestry they know or whose matings they attempt to control in order to obtain desirable offspring. Country children have had wide experience with budding, grafting, and the purchase of nursery trees, with a parallel destruction of seedlings. They have heard of the desirability of "settings" of eggs from favored flocks, the saving of the best corn for seed, and know of the high prices paid for certain bulls and stallions. All children have been told that they "take after" their parents or their grandparents or else "don't look a bit like the rest of the family," the latter statement sometimes causing great anguish by confirming a belief that they are adopted. They have heard that red hair, drunkenness, bad temper, musical ability, and tuberculosis "run in" certain families. They have heard "like father like son," "a chip off the old block," "traits skip generations," "girls take after their fathers, boys after their mothers," and a variety of other proverbs which formulate a belief in the inheritance of traits and a guess as to its mechanism. They have heard of "half breeds," of Eurasians, of people with "Negro blood," often associated with the statement that people of mixed blood inherit the worst traits of both races. In some places they have been

taught to share a more active "race" prejudice against people of a particular color or language or standard of living. They have heard individuals referred to as "born teachers," "born politicians," "born liars," or, like the nineteen-months-old baby referred to in the papers recently, as "natural murderers."

Older children will have studied our immigration laws at first with a complacent feeling that races and individuals who are excluded would be poor parents for future generations of Americans, later perhaps with a vague uneasiness based on recognition of the fact that we are all of "foreign" descent. There is here an emotional element not present in thinking of dogs or seed corn. This emotional element is also present in the common misconceptions of natural selection and the survival of the fittest, the confusion of the poor and weak with the unfit, and the resulting belief so often heard or read about in these days, that "The poor ought not to be allowed to have children"; "America is breeding from the bottom, not the top"; "We shouldn't take such good care of the weak and sick because it simply allows them to stay alive and perpetuate their kind, thus going against natural selection and causing the race to deteriorate." This has seemed to be given scientific backing by uncritical use of the stories of the Jukes and the Kallikak families in elementary studies of human heredity. Those who read newspapers or study current problems in school have been impressed and perhaps puzzled by the fervor with which racial superiority is being proclaimed in Germany and by the drastic measures being taken to preserve racial "purity."

A unit on heredity may grow out of many such situations originating outside of school and also from situations arising in biology classes, in other science classes, in social-studies and English classes, etc. Some of the larger areas of study out of which a unit on genetics may be formed, or into which it may lead, include: evolution; human physiology; study of growth and/or reproduction; study of child care and development; elementary psychology; courses in "human relations"; social-studies courses where such problems as crime, heredity and environment, race, etc., have come up. More specific situations are suggested below:

A. Examples of situations arising *outside of science classes,* include the following:
   1. Discussion of situation involving heredity as found in a novel,

play, or historical incident. Example: incident in *Victoria Regina* where Victoria is urged not to marry Albert because of haemophilia, or Mrs. Tarleton's ideas regarding inbreeding in Margaret Mitchell's *Gone With the Wind,* pp. 88–90

or

2. Discussion of current political policies with regard to races in Germany

or

3. Discussion of what makes a good mate, or discussion of differences in people, their causes and resultant problems

or

4. Newspaper or magazine articles on progress in plant and animal breeding

or

5. Newspaper or magazine articles on "freaks," on inheritance in the Dionne quintuplets, on Mr. X's views on the cause and the control of crime, etc.

or

6. See "Topics for Discussion" under *Suggested Experiences,* for additional topics, some of which might be used as introductory material.

B. *In a biology class,* work in heredity may grow out of many situations. The following suggest approaches for use in some classes:

1. Compile questions asked by class during term. Call attention to one or more of them. The following are samples of the kind of questions students (of various ages) ask:
   Why do children "take after" their parents?
   What makes brothers and sisters grow to different sizes, if they eat the same food?
   Why does red hair seem to run in a family?
   How much influence do ancestors have on any one's life?
   Will a child be musical if his mother plays the piano a lot before he is born?
   Do bright people always have dull children?
   Is it really bad to marry your cousin?
   If the boy I want to marry is intelligent and healthy, does it matter what kind of parents, grandparents, brothers, or sisters he has?
   Have we a right to sterilize people?
   Is it anybody else's business who marries whom?
   Is there any chance of breeding a better human race?
   How have new kinds of plants and animals been produced?
   Can enough food be grown for all the people on earth to have as much as they want?
   What do the Germans mean by the Nordic Race? Is it superior?
   What makes a person a criminal? Are criminal tendencies inherited?

or

2. Utilize discussion of a particular superstition or proverb (e.g., prenatal influence) to precipitate a unit on heredity.

or

3. Ask the class members if they know what is meant by heredity. Is it a coincidence that you look like your parents? What are some things you seem to have inherited? Is complexion inherited? Is stature inherited? Is intelligence inherited? Is sex inherited? Is death inherited? Is money inherited? Etc. Does a trait always show? Can you inherit from grandparents even if your parents don't show traits?

or

4. Investigate inheritance of some human traits by looking up data at home on your own family (e.g., left-handedness, blue eyes, musical ability, color-blindness). Bring these family histories to class. The difficulties involved in the direct study of human heredity quickly become apparent. Solution: experimental animals. Set up breeding experiments.

or

5. If the class has been studying reproduction, draw attention to the fact that the germ cells are the only physical link between parents and offspring. Lead discussion on to consideration of what is inherited and how.

or

6. Take a field trip to a stock farm in the neighborhood or to any farm where pure-bred stock or fancy varieties are a specialty. Which of these varieties were not in existence fifty years ago? How were they developed?

or

7. Make a similar trip to a greenhouse, large garden, large city fruit or vegetable market.

or

8. Make a trip to the city markets or several farms including large, small, progressive, and backward ones. (See Kinsey, *Field and Laboratory Manual.*) Make notes on best variety of each kind of animal (horse, cow, hog, chicken, etc.) seen in the market or on each farm. Give especial attention to the number of varieties of each animal on each farm or in each shipment to the market. Is each farmer raising a single variety (a pure breed) of each animal, or does he take anything (mongrel or scrub) that comes along? Which method has given the farmer the better results?

or

9. Use in the laboratory animal families in which the offspring do not all resemble the parents, to precipitate discussion of why and how. A litter of kittens, pups, or rabbits together with their mother may be brought to the classroom for this purpose.

or

10. Utilize chance reference to some famous forefather. Ask how much one famous forefather is worth, etc.

or

11. Lead a discussion of reproduction into a discussion of heredity.

or

12. Present a protest. If properly prepared and administered, this can be an interesting and enjoyable introduction. Such "true-false" statements as the following might be used:
    a. A wise farmer will sell his largest and finest ears of corn, which bring the best market price, and save the poor ears for seed.
    b. Hens can be developed which lay eggs almost every day of the year.
    c. A blue-eyed child may be born to two brown-eyed parents.
    d. Some children at birth have tuberculosis inherited from tubercular fathers.
    e. No two things are ever exactly alike.
    f. Environment produces variations, but heredity does not.
    g. Bad habits may be transmitted to the next generation through heredity.
    h. Measles and chicken pox are inherited.
    i. Desirable as well as undesirable characteristics may be inherited.
    j. Acquired injuries are inherited.

or

13. Tell the story of Gregor Mendel. Children may suggest Luther Burbank's work and pave the way for the study of genetics in modern agriculture.

or

14. Discuss a problem situation. This may well arise without teacher planning. For example, in a local newspaper there is a syndicated column in which, almost every week, there appears some letter such as this fictional one: "I am engaged to marry a fine man, but his aunt went crazy before she died. If I marry him, will my children be feeble-minded?"

or

15. Some of the student experiences suggested in the next section can be adapted for use as introductory experiences, e.g., the experiment on taste-blindness readily precipitates discussion and investigation as to why people differ.

IV. SUGGESTED EXPERIENCES FOR STUDENTS

This section is intended to serve as a "source list" of useful experiments, demonstrations, projects, discussion topics, etc. In the

description of each, as many helpful suggestions are given as space permits. This list of experiences makes no pretence of being exhaustive, but is intended to be as richly suggestive as possible. Like the rest of the source unit, this section is also for the teacher's use, not for direct use by students. It is expected that each teacher will select from the "source list" whatever student experiences seem appropriate to his purposes, that he will modify them where necessary to meet his students' needs, and supplement them as desired with teaching material of his own. A few of the experiences in the source list are original; the rest are adapted from a wide variety of sources. All the experiences suggested have been tested on students; most of them have been used by the author with her own classes. In cases where the experiences are described in terms of the senior high-school student, the teacher who understands younger children should have no great difficulty in selecting those which are appropriate to the needs of younger students, and adapting them for this use.

Since most experiences may serve a number of objectives, it seemed better not to organize them around topics but to group them under the following headings: breeding experiments, experiments for use with large groups, additional projects for individuals, and discussion or reading topics. Nowhere does the order in which the experiences appear in the source list have any bearing on the order in which students will use them.

A. *Breeding Experiments—Group or Individual Projects* (*See also laboratory references in bibliography.*)

The best animals are probably mice and fruit flies. Mice have appeal as pets yet cost less to buy, to feed, and to house, and reproduce faster than larger mammals (gestation lasts nineteen days, and the F_2 generation can be produced in the same semester as the original cross). Fruit flies reproduce quickly (one generation every ten days or two weeks) and are easily handled. Working with them gives insight into experimental methods in research and provides experience in interpretation of statistical data. The experimental work, easily feasible through the use of flies and mice, will furnish a basis for almost every aspect of theoretical genetics that one wishes to develop.

1. Mice

Cross for coat color factors (for example, color vs. albinism, agouti vs. non-agouti, spotting vs. solid color, black vs. brown); also pink eyes, short ears, waltzing; single factor, two-factor crosses.

Cages. Glass aquaria with wire tops may be used as cages. More elaborate cages may be constructed of screening or metal in such a way as to provide feeding racks for dried biscuit, etc. Inexpensive cage (about 15 cents) may be made as follows: Cut rectangle of wire screening, 10" x 24", roll into cylinder and fasten with paper clips. Cap cylinder top and bottom with five-cent cake tins. Use paper towels spread fresh daily on bottom tin to facilitate cleaning. Coffee can with hole in side and shredded newspaper inside provides draft-free nests. Small cream jar (kind used for individual coffee) may be used as water cup or a hanging drop may be used or a lettuce leaf may be supplied daily, supplemented by a cup of milk left overnight three times a week.

Food. Dry bread crusts or dog biscuit, lettuce leaf, plus cup of "standard ration" (four cups whole-wheat flour to one cup dried milk and one tablespoon salt) with separate cup of water. Table scraps may be used, but where feasible the above ration is cleaner, simpler, and can be prepared in quantity.

Suggestions. Use results of experiments to demonstrate Mendelian Laws where genotype of original animals is known, or use Mendel's Laws to figure out from results of breeding the genotype of original animals when genotype was unknown. Students enjoy making wall charts to indicate predictions or results, and sketches or photographs to illustrate their reports. Oral reports furnish opportunity for good discussions involving reflective thinking; for example, which of the conclusions that might be drawn from the data are definitely proved, which merely probable, which irrelevant?

One good place to obtain mice of any desired genotype is from the Supply Department, Roscoe B. Jackson, Memorial Laboratory, Bar Harbor, Maine. Prices range from twenty-five cents to two dollars per mouse.

2. Fruit Flies (*Drosophila melanogaster*)

Use standard media: cornmeal-molasses agar, or banana-agar, in one-half pint wide-mouthed bottles (See Turtox Science Leaflet No. 15.)

Crosses can involve characters visible without microscope and illustrating simple Mendelian inheritance (for example, ebony body, vestigial wings) or sex-linked inheritance (white eyes, yellow body, etc.). An entire generation of fruit flies takes two weeks to develop (or ten days in an incubator at 80° F.).

The strains of Drosophila mentioned above, and others, may be purchased from the General Biological Supply Company, Chicago, Illinois, and from Ward's Natural Science Establishment, Inc., 302 Goodman

Street, North Rochester, New York. Flies should be ordered about a month in advance of the time they are needed.

3. Other Animals

a. Guinea pigs. Rough vs. smooth hair, spotting vs. solid color, etc. (N.B. These make excellent animals for incidental sex education with students of junior high-school age, since the young have fur and open eyes at birth and hence appeal as pets.) Gestation, sixty-five days.

b. Rabbits. Angora vs. short hair; many coat color factors. Gestation, thirty days.

c. Rats. White vs. hooded, color vs. albinism, etc. Gestation, twenty-one days.

4. Corn

Green color vs. albinism, is a unit character which illustrates admirably the 3:1 ratio. Plant hybrid seed in window boxes or seed flats. Seedlings appear in about ten days. Hybrid seed may be obtained from Myers Hybrid Seed Corn Company, Hillsboro, Ohio. See also B 5 below (use of F_2 ears of corn to demonstrate Mendelian ratio). Some students living on farms may be interested in actually raising these crosses from hybrid seed.

References for Breeding Experiments

See Bibliography, especially
Adventures in Biology
Field and Laboratory Manual, Kinsey
The Laboratory Mouse, Keeler
Turtox Service Leaflet No. 15

B. *Demonstrations and Experiments That Can Be Used with Large Groups*

1. Mendelian Law: *To illustrate principle of simple Mendelian inheritance (3:1 ratio); some points about statistical data and probability*

Dye 200 lima beans blue, 200 brown (to represent graphically the factor for brown and blue eyes). Make two piles, each containing 100 beans of each color. Mix thoroughly. Let a blindfolded student draw two beans, one from each pile. Keep record of sequence of 100 draws. Demonstrate 3:1 ratio. Discuss reliability of basing ratios on a few cases. Is every fourth draw always two blue beans? In families of fair children, what combinations of blue and brown are possible? Which are more probable? etc.

2. Taste-Blindness—an example of a simple Mendelian inheritance in humans

Let the class taste phenyl-thio-carbamide. It will seem very bitter to "tasters," but about one-fourth of the population are "non-tasters."

LIBRARY OF THE UNIVERSITY OF ALBERTA

Non-tasting is a Mendelian recessive (but it has a high mutation rate so that there are occasional exceptions).

Obtain a supply of phenyl-thio-carbamide from Eimer and Amend, 205 E. 18th Street, New York City, or other chemical supply companies. Taste a few small crystals adhering to a toothpick or dissolve in alcohol, dry on filter paper, and chew a small amount (square cm.). Take samples home and report which, if any, members of the family are non-tasters."

3. Blood Groups (*Multiple Allelomorphs*)

Test blood types of students. Discuss implications for blood transfusions, for establishing parentage.

Group A and Group B serum is obtainable from companies like Parke-Davis, 181 Hudson Street, New York City. ($10 for 1 cc. of each; will type about fifteen students Group A and Group B. $2.50 for "bedside package"; will type one patient and donor.) Perhaps near-by hospital will perform typings or furnish serum. It typings are performed in classroom, take proper precautions to avoid infection when pricking to obtain drop of blood. Good discussion of blood groups in Snyder.

4. Color-Blindness (*Sex linkage*)

Test for color-blindness. Especially interesting in large mixed class of boys and girls. In cases where color-blindness is found or reported in other members of the family, collect family histories.

Color-blind test charts may often be borrowed. For accurate testing: Ishihara's "Test for Color-blindness" may be obtained from C. H. Stoelting Co., 424 N. Homan Avenue, Chicago, Illinois (Price about $7.00); or "Tests for Color Blindness, Visual Acuity, and Astigmatism," by Milton B. Jensen, obtainable from Psychological Corporation, 522 Fifth Avenue, New York City ($3.50). The former, however, is worth the additional cost.

5. 3:1 Ratio in Corn (*Also 9, 3, 3:1*)

Let each student make counts on corn ears simultaneously: red-white, purple-white, starchy-sweet, or two-factor combinations of these. Contrast results from their counts of a single row with averages from counts of whole ears. (Corn ears obtainable from biological supply companies, also from G. Carter, Clinton, Connecticut. Insist on ears with distinct rows of kernels.)

6. 3:1 Ratio in Drosophila

Let students who are studying Drosophila prepare enough F_2 bottles from their F_1 of ebony-gray body cross so that there is an F_2 bottle for each member of the class. Remove flies, etherize, and count. Compare results from single bottle with totals for all bottles. Discuss reasons for variation in ratio in different bottles and reasons for variation in total number of flies hatching.

7. Heritable and Environmental Variations (*Largely qualitative*)

(Studies of types of variations for the purpose of providing concepts of both heritable and non-heritable variations as a foundation for un-

derstanding that both complexes of factors are effective in determining the development of an organism.)

a. Non-heritable variations—largely qualitative (environmental variations). Recall all available information on previous nutrition experiments executed with genetically homogeneous animals, or carry out some of these experiments (as individual or group projects). Grow cuttings of some plant (for example, "Wandering Jew," sweet potato, white potato, etc.) under extreme variations of light, temperature, mineral nutrients, etc. Does environment make a difference?

b. Heritable variations—qualitative. Utilize materials given above in this section and in the section on breeding experiments to demonstrate heritable variations.

8. Variation in Quantitative Characters *(continuous variation)*

(*(a)* and *(d)* below are especially recommended if time is limited.)

a. Interaction of many pairs of hereditary factors operating cumulatively on an observable character. Coin-flipping experiment as analogy. Each student in the class flips a coin. Record number of heads each time for 100 or 200 flips. Result is approximately "normal distribution," representing the effect of a large number of factors (coins). "Normal distribution" histogram can be constructed on blackboard or with child's blocks by letting different columns represent the number of heads per throw and adding a square or a block to the height of the appropriate column after each flipping. Compare with case of one-factor pairs, of two-factor pairs, etc.

What would be the possible effects of variations in environment on this distribution? (smoothing, skewing, elimination of certain ranges, etc.)

b. Effect of environment varying (heredity constant). May be demonstrated to the class by one student or by a group. Inoculate twelve test-tubes containing lukewarm, melted beef-agar medium (sterile) with one loopful each from a beef-broth culture of an air bacterium (originally obtained by exposing a Petri dish and incubating at room temperature). Shake tubes thoroughly, and pour quickly (before agar congeals again) into twelve sterile Petri dishes. Keep each pair of plates at a different temperature for several days (for example, in ice-cube tray of electrical refrigerator, in main part of refrigerator, in cool place, at room temperature, at various warmer temperatures, at the temperature of a pressure cooker). (In this experiment heredity is assumed to be essentially the same for all bacteria because each colony on the first agar plate has developed from one or at most a clump of only a few bacteria. Thus all subsequent bacteria used in the experiment are the descendants by a sexual reproduction of the founders of the colony.)

Examine for colonies. If there are too many colonies to count, there is a chance to discuss how reliable sampling can be done. Plot the number of colonies that lived and grew at each temperature. What kind of distribution is there? What assumptions are you making?

Would all bacteria give the same distribution? Would all environmental differences result in a distribution curve having the same shape? (How about exposure to varying amounts of sunlight, or disinfectant?) (Direction for culture medium and techniques: see elementary bacteriology text, e.g., Broadhurst and Given, *Bacteriology Applied to Nursing.)*

c. Environmental "Fluctuations" (for advanced students). Look up Johannsen's classical experiment on the distribution of sizes in beans after stock was homozygous for bean size (discussed in Sinnott and Dunn, p. 284; Snyder, p. 251, etc. See Bibliography—A). Plot distribution from data given. These results were due to fluctuations in environment that were beyond control. What further effect might be expected if other environmental changes occurred? Compare with results of coin-flipping.

d. Combined effects of hereditary and environmental differences: distribution of heights of school pupils. This experiment is suitable (perhaps in simplified form) for even the youngest students. Let all the members of the class stand up against the wall so that the shortest is at one end and the tallest at the other. In what part of the line is there the least difference in height from person to person? Plot frequencies on board, discuss interpretation; for example, what is "average" height? How many students are exactly "average," etc.? What evidence can you suggest for believing that height is partly hereditary? Partly result of environment?

Repeat experiment with weights of group, etc.

Some students may wish to carry out this experiment as an individual project, with larger groups of data. See 11 and 12 below.

9. Fallacy of the "Heredity versus Environment" Argument *(Blackboard demonstration)*

Yellow fat *yy* is a unit factor recessive to white fat *Y*—in rabbits. White fat is due to the action of an enzyme from the liver which breaks down xanthophyll in food.

Y—white fat
yy—yellow fat
} Simple Mendelian recessive as long as animals are fed green food. Seems a purely hereditary factor.

If *yy* animals are fed mash with potatoes, however, no xanthophyll is present; consequently the fat is white. Hence yellow versus white (in a breed of animals which are of the *yy* strain) would seem obviously to be due entirely to environment:

Compare this case with *S* (immunity to diphtheria), *SS* (susceptibility), and the environmental factor of contact or lack of contact with a diphtheria carrier.

Similarly, inherited aptitude for musical training and opportunity for developing musical talent.

10. Behavior of Chromosomes

Use models representing chromosomes to demonstrate mitosis, reduction, division, crossing-over, etc. Devising and making such models

of plasticine, beads, or thick rubber tubing with painted segments, and demonstration is an excellent project for individual students.

11. Real Chromosomes

Microprojection of slides of Ascaris, onion root, or lily root, etc. For many students, the presence of chromosomes and their paired arrangement is significant, but all the details of mitosis have meaning.

Giant Chromosomes from the Salivary Glands of Drosophila.

The American Genetic Association,[8] Victor Building, Washington, D. C. (which publishes the *Journal of Heredity*), will supply:

Microscope Slides of the giant chromosomes ($2.25 each, 3 for $5.00).

Lantern Slides with drawings of the giant chromosomes (75¢).

Reprints of the large "maps" of the giant chromosomes originally drawn by Bridges and by Painter for the *Journal of Heredity* (December, 1934, and February, 1935, respectively. The latter drawing is 18" long). Price varies for different drawings, but is about 75¢.

12. Sex Chromosomes

Show sex chromosomes in demonstration microscopes. See biological supply catalogues for appropriate slides, e.g., Anasa tristis (the squash bug).

13. Further Practice in Reflective Thinking

Tests on the application of principles, interpretation of data (see Section V—Evaluation), etc., form an excellent basis for lively class discussions. The diagnostic and testing value of such instruments is hardly more important than their potential teaching value. Construction of test items (of all kinds) by students is possible, in addition to discussions following the tests. Student reports on experiments similarly afford excellent opportunities for emphasis on reflective thinking. See also Section D below on discussion topics.

14. Further Experiments

Some of the experiences described in the section on "Introductory Work" may be found useful in the body of the unit instead.

[8] Other materials supplied by the American Genetic Association include:

1. *Biological Movie Booklets,* drawn by Clyde Keeler. These are booklets with one drawing on each page, each drawing a bit different from the preceding, so that when the pages are flipped, a movie-like effect is produced. Movie booklets of interest for this unit are: Booklet I, "Normal Cell Division" (50¢); Booklet II, "Maturation of Sperm" (70¢); Booklet III, "Fertilization" (60¢). All three for $1.50.
2. Leaflets to Demonstrate Taste-blindness (10 for 25¢, 50 for $1.00). A small sample of phenyl-thio-carbamide is included in each.
3. Lantern Slides on Heredity. A list of 90 slides (75¢ each). Made from illustrations that have appeared in the *Journal of Heredity.*
4. Reprints of articles that have appeared in the *Journal of Heredity.* (Usual price 10¢ to 20¢ each.)

Descriptions of all the materials mentioned can be found on the back covers of various recent issues of the *Journal of Heredity.*

15. Human Family Histories (See B 4 under "Introductory Work")

Let as many members of the class as wish to do so, make a record of some interesting characteristic that appears in several members of their own family (or some other family they know). Summarize pedigree data in a diagram of the family history. Answer as many of the following questions as possible: "Is the character clear-cut (a person either has it or doesn't have it), or are various degrees of expression possible?" "Do both sexes show it in approximately the same numbers?" "Does it ever appear in a son or daughter when neither parent shows it?" "If both parents show it, do all the children show it?" "Would the expression of the character be influenced markedly by the environment?"

If these pedigrees are made early in the unit, file them away, and examine them later to see whether more definite interpretations can be made. (The Eugenics Records Office, Cold Spring Harbor, New York, will furnish blanks for recording family histories. They request that duplicates of the histories be returned to them for their files.)

C. *Additional Projects for Home or Laboratory*

These projects are chiefly individual projects, but many can also be used for class demonstration.

1. Make wall charts predicting results of your breeding experiments. To facilitate work and improve appearance, a stencil, of a mouse, for example, may be cut from stiff paper and traced as many times as needed. Another example: one-factor and two-factor fruit-fly crosses.

2. Make similar charts of actual results of breeding experiments.

3. Make lantern slides to illustrate various topics to the class; e.g., the results of an experiment, an interesting pedigree, diagrams explaining various kinds of crosses, diagrams of mitosis, of meiosis, drawings of chromosomes of Drosophila, of giant chromosomes, etc.

4. Make photographs of litters of laboratory animals to illustrate reports.

5. Microscopic study of chromosomes. Make careful drawings. Some students will also want to draw the stages of mitosis. Ascaris are good for this, also onion and lily-root cells.

6. Make careful drawings of chromosomes when *XY* chromosomes can be seen, etc. (For slides see Turtox catalogue, Bibliography—E.)

7. Take photomicrographs of chromosomes.

8. Make big models of chromosomes to demonstrate chromosome behavior to the class.

9. Draw giant chromosomes of Drosophila from specially prepared slide (Turtox, etc.). Make wall chart representing these chromosomes.

10. Conduct extensive coin-flipping or bean-drawing experiments to explore probabilities. Record results carefully.

11. Studies in individual variation in humans. Record heights (or weights—or other data) of all children of the same age in school. How

does this distribution differ from the one in which only your classmates participated? In what ways do you account for the variation in heights? etc.

12. Studies of individual variation in plants.
    a. In beans. Determine how much variation there is in a cup of lima beans (dried beans). (This is not Johannsen's experiment.) Be careful to get a package containing beans of various sizes. Arrange beans in rows according to longest dimensions with 1/16″ difference in rows. Record observations on graph paper. Are these variations environmental or hereditary, or both? (Both, probably, for most sources of beans.)

    or

    b. Record variations in a large number of leaves of the same species:
    (1) Length
    (2) Number of veins
    (3) Number of leaflets
    c. Do the same for the number of ray flowers in daisies or sunflowers.
13. Study growth of population of fruit flies in pint bottle. Interpret and account for the curve obtained.
14. Visit nurseries, greenhouses. How many of the kinds of plants you find there were not yet developed fifty years ago? Make this same observation at cattle shows, dog shows, county fairs, etc.
15. Suggestions for special investigation and report are scattered through Section D below. See especially D 4 for applications of genetics in agriculture.

D. *Topics for Reading, Class Discussion, Special Reports, Panel Discussions, or Debates*

These topics are merely suggestive. Every teacher will probably want to modify and supplement them. Some of the topics which seem offhand to be suitable only for older students, can be restated much more simply for the younger students.

Suggested topics are listed under the following five headings:

1. Human genetics, development of the individual, personal relations
2. Possibilities of race betterment
3. Race and population problems: war, immigration
4. Plant and animal genetics
5. Miscellaneous

1. *Human genetics, development of the individual, personal relations*

Make a list of some human characters which might readily be in-

fluenced by changes in environment. What environmental changes? List some that could not easily be influenced.

List some human characters that do not appear until late in life. Will these be hard or easy to study?

What can you find out about your own pedigree?

Make a list of heritable human traits indicating the mode of inheritance in each case. How many of these are relatively rare? How many are desirable, how many undesirable? How long a list can you make of either common or desirable traits whose mode of inheritance is well known?

Study a human pedigree: Explain the symbols. How can you show which traits are dominant? Recessive? How much can you predict about the next generation in this family?

In which diseases of man is heredity important? In which is environment important? Do your lists overlap?

What contributions has genetics made to medical knowledge? What are the probable future contributions?

If you wished to ascertain whether insanity tends to be associated with genius, how would you investigate the problem, and what sources of error should you guard against?

The hereditary basis for mental traits has been much harder to establish than that for physical traits. Can you suggest some reasons for this?

Is blindness hereditary? What would be a better way of stating this question?

Suppose one of your friends is in love with his cousin and wants to marry her. He comes to you for advice. What would you tell him?

What relationships exist between occupation and family size? Nationality and family size? Income and family size? Are these three correlations independent? How would you allow for the fact that nationality groups have been selected as to income? What relationships exist between living in the country and living in the city? Account for the differences if you can.

What are the advantages and what are the dangers of inbreeding? How does this apply in agriculture? In human marriages? What legal restrictions, if any, should be placed on consanguineous marriages? What laws in your state affect choice in marriage? Which of them are desirable and which the reverse?

List the hereditary defects which, in your opinion, should constitute a legal barrier to marriage.

What characteristics in a person would make you unwilling to marry him or her? Which of these would your children possibly inherit?

To what purposes can a knowledge of blood groups be put? In genetic research? In cases of disputed parentage? In medicine?

Compare the number of chromosomes in various animals, in various plants, and in man.

Write a summary of the ways in which environment can affect the individual.

Study famous pedigrees.
Report on studies of identical twins.

2. *Possibilities of race betterment*

If you were perfectly free to experiment with human beings to find out more about human genetics or to improve the race, what experiments would you try?

What hereditary traits might dispose people to commit crimes? What environmental traits? What is a criminal? Does this word mean the same thing in all countries? Are there criminal types?

Is the sterilization of criminals a justifiable procedure, on biological grounds? On the ground that it would promote social welfare? Is there a high crime rate in the United States?

From the standpoint of biological fitness, is it better for the human species to live under conditions which entail a high death rate? Does modern medicine weaken or strengthen the human race by keeping alive many people who in olden times would have died much sooner?

List in one column the forces which are acting eugenically and in another those that are acting dysgenically. (Compare this list with a similar one made for primitive society.)

Make a list of feasible measures for promoting race betterment. What practical difficulties are involved?

List the arguments for and against birth control.

Is there a sterilization law in your state? If so, how does it function? Are adequate records available as to the success or failure of the plan?

If there is no sterilization law in your state, discuss the reasons for this fact. In your opinion, are these reasons adequate?

The Declaration of Independence states: "We hold these truths to be self-evident, that all men are created equal. . . ." Discuss this statement from the genetic standpoint.

What changes of environment are desirable in your city (or county) and where? How do you think these changes could be made?

3. *Race and population problems, war, immigration*

What is a race? Can you say that one race is superior to another? What are the results of racial intermarriage?

How do races differ in their susceptibility to disease?

What do you think of the relative importance of the following influences on the birth rate: religion, income, education, social position? How would you check your guess?

What effect has immigration had on the genetic character of the population of the United States?

What efforts have various countries made to increase their birth rates? To breed a better race? Spartans, Romans, modern Italians, Germans, etc.

What is the average size of the family in the class to which you belong? Does this indicate a birth rate sufficient for maintaining the stock under existing rates of death and marriage? What importance, if any, do you attach to this?

Does war have any biological consequences?

Compare the effects of primitive warfare with those of modern warfare from the standpoint of biological evolution.

How does war affect the mixture of different racial stocks? Consider in this respect the history of England and that of Rome.

Does the acceptance of the Darwinian theory of natural selection logically involve the justification of war on biological grounds?

If you wished to evaluate the net biological results of a war, what statistical data would you find advantageous to possess?

Does the means of supporting life increase in an arithmetical ratio as Malthus once stated? If it does not, what effect does this have on Malthus' doctrine?

If there were fewer people in a country, would there be less unemployment?

On the whole, do you think that cities attract the most intelligent, or the least intelligent of the rural population? How do city and country compare as to the physical development of their children? From the standpoint of maintaining health, what are the advantages and disadvantages of large cities as compared with rural areas?

In your opinion, are there any stocks in the United States which are undesirable additions to our population?

In what ways should immigration into this country be regulated?

What do you consider the more important, the social or the biological consequences of racial intermarriage? Do you think race mixture will proceed more rapidly as time goes on?

4. *Plant and animal genetics*

How are new breeds of animals produced?

Why are apples, peaches, and other fruits propagated by buds or grafts? What commonly happens when these fruits are raised from seed? Why?

How did Burbank make so many new kinds of plants?

What aid in genetics does the government offer farmers?

What effect has the potato and its diseases had upon the population of Ireland?

Find the points in pedigreed dogs, horses, or cattle by which they are judged by fanciers. Give the points which have been combined to produce certain prized varieties of corn, wheat, cotton, sheep, poultry, or cattle. Collect pictures of pedigreed animals which illustrate unit characters.

List all the known varieties of one kind of domestic animal, for example, cow, dog, horse, pigeon.

Read and report on the development of

Java sugar cane	Meat
Wheat	Flowers (new)
Maize	Milk production of cows
Vegetables (new)	Egg production of hens
Soy bean	Etc.

Determine the origin of various vegetable foods. Of plants used for other purposes than food.

Investigate "plant patents" (patent rights are now granted on new varieties of plants as they are developed). What are the implications of this? Also, what is its meaning from the standpoint of genetics?

To what extent are the best varieties of plants and animals now known to man actually used?

What investigations in plant and animal breeding does the United States Department of Agriculture carry on?

5. *Miscellaneous*

How does our knowledge of genetics contribute to the theory of evolution?

Examination of common superstitions involving genetic questions.

How many proverbs can you find involving genetical lore or the influence of environment? How many of these can be paired to say opposite things?

Report on interesting current articles from the *Journal of Heredity*.

Read and report on the lives and work of

Mendel	Burbank
Weismann	Galton
Darwin	

V. EVALUATION

To How Great an Extent Are the Stated Objectives Actually Being Achieved?

In accepting the philosophy of the report, we have accepted also the responsibility for doing something about evaluation of student achievement.

In Part I of this unit we stated, to the best of our ability, the objectives toward which our teaching was to be directed, the outcomes we hoped for. We were as concrete as possible in that we did not say merely that we intended to help develop the student's world picture, or his self-understanding, or his ability to think reflectively. We went on to say in Part I what particular aspects of the world picture, of self-understanding, of reflective thinking we meant.

How do we know, however, that we have accomplished these various phases of our objectives? Or, if we have accomplished them, that, summed up, they aid the student in meeting his needs or in developing in himself those desirable characteristics of personality at which we are aiming? The answer is, of course, that we shall, at best, know only imperfectly whether or not our efforts have taken root, for evaluation of this sort is still quite new.

Our limitations are two: (1) the absence of a full battery of efficient evaluation instruments, and (2) available time. That is sufficient acknowledgment of limitations. Bearing them in mind, what are the practical things we can do about evaluation—specifically in regard to the outcomes of a unit in genetics?

Examination of the major objectives suggests that growth toward these objectives depends on the production, in students, of *several kinds of changes.* From the standpoint of available evaluation techniques these can be conveniently grouped under three main headings:

I. *Development of new, or more complete and more accurate, "understandings"* (the acquisition of information and the synthesis of such information into larger understandings)
II. *Progress in ability to use scientific methods (and attitudes) in thinking and behaving*
III. 1. *Progress toward the development of other desirable personality characteristics* (as shown by attitudes, appreciations, skills, interests)
2. *Evidence that the student is actually using these various tools* (understanding, thinking, attitudes, interests, etc.) *in meeting his particular needs,* e.g., in achieving self-assurance, in working out a satisfying and consistent world picture, etc.

In this evaluation section of the genetics unit we shall present chiefly sample items illustrating the application of some of the techniques of Chapter IX to genetics materials, plus some comments here and there on other ways in which certain techniques can be used.

Concentrate on a few objectives. In actual practice (at present anyhow) few teachers will have time to check up on every student's progress on every phase of each possible objective of this unit. Hence the teacher will probably find the end result most satisfying if he decides which objectives are most important for his student group, selects some of the techniques appropriate for evaluating

these few objectives thoroughly, and collects as much evidence on the remaining objectives as there is time for.

I. *Development of New, or More Complete and More Accurate "Understandings"*

Practically all the techniques suggested in Chapter IX (page 388), for evaluating progress toward informational objectives are in general use. Essay tests, recall tests, multiple response, completion, master lists, matching tests, true-false tests, cross-out tests, are all familiar techniques. It seems unnecessary to illustrate these.

Comment. It is useful, when beginning to teach the unit, to set down (for one's own use only) a list of all the generalizations which a particular group of students should come to understand in view of their objectives, for example, every observable character is the result of *both* heredity and environment. It is assumed that the same laws that apply to plants and animals will apply to man. Variation is universal. Normal does not mean the same thing as average, etc. A similar list may be made of all the terms and concepts to be introduced, for example, gene, mutation, chromosome, 3:1 ratio, etc. Such a list varies from one group of students to another, depending on their age, the function of the unit in their total program, etc., and would probably be modified further during the progress of the unit.

II. *Progress in Ability to Use Scientific Methods (and Attitudes) in Thinking and Acting*

This objective is dealt with separately because it is one of the major objectives of science teaching, and evaluation techniques for it have been developed in detail. (See Chapter IX, page 396.)

Some techniques other than tests follow:

1. *Anecdotal records* are one technique for recording incidents, for example:
   (*a*) Evidences obtained by observing or talking with a student at work on a project:
   JOAN: Heck! This experiment doesn't prove after all that brown fur is recessive because I used a black male mouse and a brown female. But if I mated two of their black children, these would be heterozygous for brown *if* brown is recessive, and if they had some brown children, then I would have proved that brown is recessive.

(*b*) Evidences obtained during class discussions (Evaluation of authority):

WINIFRED: But it says in the advertisement that he is a specialist, so he must be.

JANE: It might mean something if he had an M.D. after his name, but I wouldn't want to trust a "specialist" who wasn't even a doctor.

2. *Check sheets* with columns for a number of typical kinds of thinking and attitudes and the names of all members of the class in a list at the left. Used for a month or two of lively discussions and class work, it provides some concrete evidences as to which students participate often and where their strengths and weaknesses lie. If sheets like this are mimeographed, one can be used for each class period. Results for many periods can be summed up on a single sheet and combined with evidences obtained in other ways (from tests, papers, etc.). Anecdotal records may be clipped to the daily check sheet when a particularly significant incident is to be reported.
3. *Analysis of reports on projects,* of papers written on special topics, etc. The above techniques may be applied to any of the abilities and attitudes listed as part of "Reflective Thinking" (Chapter IX, page 397 for list).

The following are a few sample test situations for particular aspects of reflective thinking:

Application of Principles

1. Application of general principles of specific statements (especially superstitions) as:

   Could the following be true:

   That a mother can birthmark her child.

   That bald-headedness is due to tight hat bands.

   That cousins should not under any conditions marry each other.

   That one famous forefather is worth having.

   That educating parents will increase the brain power of children.
2. Solving problems

   Color-blindness in humans is a sex-linked recessive. A girl of normal vision whose father was color-blind marries a man of normal vision whose father also was color-blind. What type of vision may be expected in their offspring? What do you know about the girl's mother? About the man's mother? Make a diagram of the family history as far as possible and label the genotypes.
3. Application of principles test (technique described in Chapter IX, page 418)

   Example III on page 417 was borrowed from this unit. In this item data are given in the form of a typical (but hypothetical) problem. Other still better items can be based on actual breeding experiments

performed by students in the class. Also paragraphs from books can be used and family histories (represented in symbols).

4. Application of principles in stating (and using) the genetic data involved in a question like the following:
   a. Suppose a friend of yours is in love with his cousin and wants to marry her. He comes to you for advice. What would you tell him?
   b. What is the best answer you could give if you were asked the question: "Is blindness hereditary?" Give reasons for your answer.

Interpretation of Data

The technique for interpretation of data is described in Chapter IX, page 403. The item below was based directly on the results of a student project in the twelfth grade at the Horace Mann School:

Directions. In each of the following exercises some test, experiment, or situation is described. Below the description you will find several statements which are suggested as possible interpretations of the data. Assume that the facts of the description are accurate. Carefully consider each of the statements and indicate in the columns to the right whether you believe

(1) The evidence is sufficient to make the statement true.
(2) The evidence is sufficient to make the statement false.
(3) The evidence suggests that the statement is probably true.
(4) The evidence suggests that the statement is probably false.
(5) The evidence is insufficient to make a decision concerning the statement.

Problem

Irva and Miriam obtained a pair of mice. The male was a homozygous non-agouti black obtained from a breeding laboratory, and the female was an agouti-brown (cinnamon) obtained in a pet store where her pedigree was unavailable. In the first litter there were seven young, although one died. Four of the survivors were black agouti, while two were non-agouti black.

Statements	(1)	(2)	(3)	(4)	(5)
a. This experiment indicates that black coat color is dominant over brown					
b. This experiment demonstrates that agouti is dominant over non-agouti					
c. The fact that no spotting appears in any of the animals indicates that spotting is a recessive factor					
d. If agouti is a dominant character, the female mouse is homozygous for agouti					

Statements	(1)	(2)	(3)	(4)	(5)
e. Two of the offspring resemble the father in their coat color					
f. The mouse which died was a black mouse					
g. Four of the surviving young are males and two are females					
h. If the same parent animals were bred together several times, about half of the offspring would be non-agouti					
i. The seventh mouse, which died, would have been non-agouti					

As in the case of "Application of Principles," many other types of data can be presented for similar interpretations: a paragraph from a book, or experimental data involving numerical results (for example, in a fruit-fly cross where one student took the F_1 bottle of a cross, made a dozen F_2 bottles using these F_1 flies as parents, and then the whole class counted these bottles. The data obtained were made into an "Interpretation of Data" test item).

Comment. The simpler (though less reliable) form of "Interpretation of Data" exercise discussed in Chapter IX, page 409, is sometimes better adapted to younger students, and is usually easier to construct.

Use of an Advertisement for an Interpretation of Data Item Similar to the Preceding

Problem

Our discussion of baldness in science class indicates that baldness is frequently hereditary, owing to a single factor which behaves as a dominant factor in men and a recessive one in women. Temporary loss of hair may be due to a disease such as scarlet fever. Certain unhealthy conditions of the scalp also may cause hair to fall. Accept these facts as true in evaluating the advertisement which appears in the 34th Street crosstown bus and reads about as follows:

ACTUAL PROOF

Photograph of bald man labeled "Before Treatment"

That I Can Grow Hair
for
Men Women Children
See me now, before it is too late!

EXAMINATION FREE

LOUIS GANT
Hair and Scalp Specialist
Established 1913

Photograph—full head of hair (same man apparently but face indistinct) labeled "After Treatment"

Statements	(1)	(2)	(3)	(4)	(5)
a. Mr. Gant can always grow hair					
b. Mr. Gant can sometimes grow hair					
c. Mr. Gant has presented proof that he can sometimes grow hair on bald women					
d. If Mr. Gant's pictures are true, as labeled, Mr. Gant has given proof that he can sometimes grow hair on bald men					
e. Both pictures are of the same man					
f. More men will seek Mr. Gant's advice than women					
g. Some baldness is known to be incurable ...					
h. A patient who comes to Mr. Gant because she has lost her hair while ill with scarlet fever will grow new hair later if she is under Mr. Gant's treatment					
i. This cure is due to Mr. Gant's treatment ..					
j. In the case of certain scalp diseases, Mr. Gant will give successful treatment					

Use of the Same Advertisement in Other Ways

a. What is actually said versus what is implied

The teacher makes up a list of statements relating to the advertisement, and the student checks each statement in the appropriate column; for example:

	Said	*Implied*
(1) I can grow hair for you		/
(2) I will make a free examination	/	

b. Assumptions involved

The teacher gives a list of necessary and unnecessary assumptions which must be made by the individual if he believes Mr. Gant could grow hair for him. The student checks all items that he recognizes as necessary assumptions.

c. Student's reasons for his own conclusions

The student checks his own conclusion in this list of three:

I believe Mr. Gant could grow hair for me if I needed it.
I do not believe Mr. Gant could grow hair for me if I needed it.
I am uncertain whether Mr. Gant could grow hair for me if I needed it.

Below this the teacher provides a list of reasons, good and bad, related to each conclusion. The student checks reasons which he believes will support the conclusion he has chosen.

d. Same form as the above except that the "conclusions" are stated as:

The ad (taken by itself, without other information) proves that Mr. Gant could, etc.

The ad (taken by itself, without other information) proves that Mr. Gant could not, etc.

The ad (taken by itself, without other information) does not furnish enough information for proof or disproof that, etc.

e. Other uses that can be made of the ad in class discussion

(1) Evaluation of authority: Is Mr. Gant a specialist?

(2) Definition of crucial terms in the advertisement. The teacher asks students to point out what words must be defined before the conclusion implied by the advertisement can be accepted.

III. (1) *Progress Toward the Development of Other Desirable Characteristics of Personality.* (2) *Evidence That the Student is Actually Using These Various Tools in Meeting His Particular Needs*

Our techniques in this area are woefully inadequate. They are fragmentary in regard to most of the personal qualities except reflective thinking and almost completely lacking on the second point—as to whether the student is actually using whatever qualities he has developed in meeting his needs.

Chapter IX, page 396, discusses some techniques for evaluating the extent to which desirable characteristics of personality are being developed. We shall discuss these qualities only in so far as this unit makes a specific contribution to one or more of them. We shall not discuss, for example, the ways in which progress in self-direction is observable, for we have nothing specific to contribute to its development. With a particular group of students the teacher may have listed that objective as a major one to pursue, whatever the "unit." In such cases, whatever help the student needs toward its evaluation, he will have to derive from other sources.

The desirable personal characteristics with which we are specifically concerned in this unit are certain aspects of tolerance, social sensitivity, personal interests, and esthetic satisfactions; certain aspects of the needs for self-understanding and self-assurance, world picture and philosophy of life (personal and social-civil) are also met by this unit.

The method of recording our observations in the situations listed below will be largely anecdotal, with whatever time-saving devices

we can develop. The situations in which teachers may have opportunity to observe changes in students' interests, attitudes, philosophy, etc., include:

1. *Written work*
   A. *Papers written for science classes*
      (1) On factual materials: for example, Mendel's work, scientific agriculture, new species of plants and animals, experiments in genetics
      (2) On controversial topics for which genetics has implications: for example, war, the Nazi program for racial betterment, eugenics, sterilization measures, a better human race, residential zoning in the community, immigration restrictions
   B. *Free writing done in other classes* evidencing new interests, attitudes, and understandings traceable to work in genetics
2. *Class discussions* on some of the topics for discussion in the source list of student experiences, or on other controversial topics
3. *Spontaneous comments* in and out of class, made or reported to the teacher
   a. Indicative of attitudes: for example, toward one's own assets and liabilities, toward others' assets and liabilities, regarding governmental policies, etc.
   b. Indicative of interests developed and carried on, and of esthetic satisfactions resulting from them
   c. Indicative of needs that have in some measure been met: for example, the admission of a student in informal conversation that some fears about his "normality" have been removed, or that the material studied "made sense" of something that had not made sense to him before (world picture and philosophy of life)
4. *Other Behavior*
   a. Have students continued or extended such class work as reading, breeding plants or animals, etc., as a result of their own interest in it?
   b. Evidences of continued interest as shown by voluntary reading, projects, reports in the school newspaper, clippings brought to class, comments and questions—after the work of the unit is finished
   c. Set up hypothetical situations and ask students what should be done—or what has been done that is not in accordance with our best knowledge on the subject. Such tests of knowledge of what to do in certain circumstances do not guarantee that a student will do what he says should be done, but the chances that he will do the right thing are increased by his knowing what the right thing is.
   d. Observation of students at work on projects

IV. *Conclusion: Synthesis of Evaluation Data Obtained*

In their crude form these types of data will usually leave the teacher with a mass of undifferentiated impressions of the progress each student has made toward developing desirable personal characteristics and toward meeting his needs. The teacher should put these data together periodically, in an effort to answer the question—what evidence is there of progress, or lack of progress, in the case of each individual student? Gradually the teacher will develop methods of summarizing these data in useful fashion.

VI. BIBLIOGRAPHY

If it were possible to find three or four books which would neatly cover the area of genetics as it has been outlined here for secondary-school purposes, the source unit itself would be superfluous. The actual situation in genetics literature, however, especially from the standpoint of the implications of genetics in human life, is somewhat complex and confusing.

A great deal of the genetics material in popular books and magazines is inaccurate and misleading; the current school and college textbooks have not yet incorporated much that is important from the standpoint of a teacher who is concerned with the educational objectives of the report; and in the more technical literature on genetics the materials that would be relevant to general education are widely scattered in many books and periodicals amid a welter of material unsuitable for or irrelevant to the secondary-school teacher's purposes.

The bibliography which follows presents the best half-hundred references for student and teacher use which the author of this unit has thus far been able to assemble out of several hundred which she has examined carefully. Doubtless, however, each teacher will wish to add other books.

It seems appropriate to make another suggestion here which it was not possible to put into effect in this volume. When a "source unit" of this kind is circulated (in mimeographed or typed form) among teachers, why should it include only the better books? It would be more helpful to us all, as teachers, if there were, in addition, a second list labeled after the fashion of Consumers Union reports, "not acceptable." This list could give particular attention

to the wide offerings of magazine articles, "popular" and semi-popular books to which we all are exposed, but which we seldom have time to explore thoroughly. Each book should be frankly and informally annotated by the makers of the unit as to its weaknesses and its strengths, and the list added to by other teachers through whose hands the unit passes.

The books recommended below are grouped under five headings: A. General and Human Genetics; B. Genetics and Evolution; C. Genetics and Social Problems; D. Genetics and Agriculture; E. Special References for Laboratory Projects. Each group is also classified according to whether it is suitable for student use or only for teacher reference.

Starred (*) books are those which the author of this unit has found particularly helpful.

A. General and Human Genetics

I. *For Students (and teacher)*

*Altenburg, E., *How We Inherit* (New York, Henry Holt and Co., 1928), vii + 273 pp. Clearly written. Not difficult. Includes basic mechanisms of inheritance, human inbreeding and outbreeding, twins, mutation and evolution, and the Negro-white cross. Emphasis on personal implications of heredity, rather than implications for social problems.

*Keliher, Alice V., for the Commission on Human Relations of the Progressive Education Association, *Life and Growth* (New York, D. Appleton-Century Co., 1938). Written in informal style and addressed to the adolescent. Discusses basic mechanisms of heredity in context of human growth and development. Particular attention to adolescent problems: understanding one's own development, human behavior, "Am I normal?" etc.

*Mitchell, U. G., and Walker, Helen, *Algebra: A Way of Thinking* (New York, Harcourt, Brace and Co., 1936), xvi + 400 pp. Contains a fine chapter on elementary statistical concepts presented at the ninth-grade level. The illustrative examples are not drawn from genetics, but with the aid of the teacher, and perhaps even unaided, the student will be able to apply the concepts to genetics.

Popenoe, Paul, *The Child's Heredity* (Baltimore, Williams and Wilkins Co., 1929), xiii + 316 pp. Described in its preface as "a guidebook for parents," but is equally acceptable for adolescent reading. An informal and detailed, reasonably accurate discussion of the influence of heredity on various physical and emotional traits.

*SNYDER, Laurence H., *The Principles of Heredity* (Boston, D. C. Heath and Co., 1935), xiii + 385 pp. Excellent college text. So clearly written that older high-school students can use almost all of it. Recommended for the teacher who wishes to brush up quickly but with some thoroughness on the elements of modern genetic theory. Some good material on mutation and evolution, also on genetics of farm animals (not much on cultivated plants that is suitable for high-school use). Three chapters devoted to inheritance of physical and mental traits in humans. A good discussion (for the teacher) of the measurement of variation.

**Secondary-School Textbooks in Biology and General Science.* Almost all the more recent biology texts and many general-science texts contain good elementary discussions of the simpler mechanisms of heredity. Some also include good material on "variation," but seldom carry this on into the topic of "normal variability" as it concerns adolescents. They usually miss a large part of their opportunity for developing reflective thinking (fact versus theory, interpretation of statistical data, etc.). Some attention is, as a rule, given to genetics in agriculture; relatively little to other implications of genetics (for example, race). (In their eugenics, emphasis is ordinarily on the classical viewpoint which diverges somewhat from that of this unit.) However, these school texts are probably among the best reading available for the younger adolescent and/or the adolescent whose contact with genetics will be very short, but they need to be supplemented by class discussions and other work, especially on the topics mentioned above.

Encyclopedias: Book of Knowledge, World Book, Compton's Encyclopedia, etc. Children's encyclopedias usually have some discussions of the elements of genetics and are included here because of their general availability in school libraries.

The Science Newsletter, published weekly by Science Service, 21st and Constitution Avenue, Washington, D. C., $5.00 per year, $7.00 for two years. This magazine contains interesting, simple, well-written accounts of what is going on in science, and includes many items relating to genetics. Most schools already subscribe to it.

The Journal of Heredity, published monthly by the American Genetic Association, Victor Building, Washington, D. C., $3.00 per year. (Sometimes offers teachers and students a special rate of four months for 50¢, eight months for $1.00.) The articles are written in a readable style so that many older students will enjoy them.

Other popular magazines frequently have articles on genetics, although these usually have to be checked for accuracy.

II. *Additional References for Teacher (too difficult for students)*

GATES, R. R., *Heredity in Man* (New York, The Macmillan Co., 1929), xiii + 385 pp. A good reference book in which to look up evidence on inheritance of a specific trait.

HOGBEN, Lancelot, *Mathematics for the Million* (New York, W. W. Norton and Co., 1937), xii + 647 pp. Contains some good material on statistics and on probability. (Possibly it could be used by older students.)

ILTIS, H., *Life of Mendel* (New York, W. W. Norton and Co., 1932), ix + 336 pp. Good biography of the father of modern genetics. Readable in part by students.

JENNINGS, H. S., *The Biological Basis of Human Nature* (New York, W. W. Norton and Co., 1930), xviii + 384 pp. Popular. On the whole too difficult for student reading, but some parts can be used by older pupils. Contains an excellent chapter entitled "Biological Fallacies and Human Affairs."

——, *Genetics* (New York, W. W. Norton and Co., 1935), xi + 373 pp. A good modern treatment of the scientific aspects of genetics.

MOHR, O. L., *Heredity and Disease* (New York, W. W. Norton and Co., 1934), xiv + 21–253 pp. A compendium of information on these subjects.

MOORE, Eldon, *Heredity—Mainly Human* (London, Chapman and Hall, Ltd., 1934), vii + 343 pp. Detailed discussion of current knowledge of human heredity. Readable and reasonably accurate.

NEWMAN, H., FREEMAN, F., and HOLZINGER, K., *Twins: A Study of Heredity and Environment* (Chicago, University of Chicago Press, 1937), xvi + 369 pp. A study of fifty pairs of identical twins and fifty pairs of fraternal twins. Reported with case histories. The study includes nineteen pairs of identical twins separated in infancy and reared apart.

SCHWESINGER, Gladys C., *Heredity and Environment* (New York, The Macmillan Co., 1933), viii + 484 pp. Very competent compendium of the known facts, especially those on the inheritance of mental traits. Summarizes a broader area than Newman, Freeman, and Holzinger.

SINNOT, E. W., and DUNN, L. C., *Principles of Genetics*, 2nd ed. (New York, McGraw-Hill Book Co., 1932), xvi + 441 pp. Good college text. Not much human genetics.

College Textbooks in general biology, botany, and zoölogy. These usually have a genetics section which is good review on the mechanisms of heredity, but rarely includes a good treatment of the implications of genetics for human living.

B. GENETICS AND EVOLUTION

I. *For Students (and teacher)*

HOOTON, Earnest A., *Up from the Ape* (New York, The Macmillan

Co., 1931), xvii + 626 pp. Readable general treatment of evolution (for older students).

*Hurst, C. C., *The Mechanism of Creative Evolution* (New York, The Macmillan Co., 1932), xxi + 365 pp. Exceedingly readable. Can be used, at least in part, by high-school students. Pays especial attention, as the title indicates, to the contributions of genetics to the theory of evolution. Makes readers realize that evolution is something that is going on now, not merely something that happened in the distant past.

II. *For Teacher Reference (too difficult for students)*

*Dobzhansky, T., *Genetics and the Origin of Species* (New York, Columbia University Press, 1937), xvi + 364 pp. A good book for the serious adult student of genetics. A modern version of Darwin. Not an easy book, but very clear, well-written, and decidedly worth reading.

*Morgan, T. H., *The Scientific Basis of Evolution* (New York, W. W. Norton and Co., 1932), ix + 13–286 pp. A clear, accurate account by a pioneer of modern genetics. An easier book to read than Dobzhansky's; written from the same general point of view, although it is not, of course, so recent or so thorough.

See also briefer treatments of genetics and evolution in such books as Snyder, Jennings, and college biology texts.

C. Genetics and Social Problems

There is a relative dearth of elementary references which discuss briefly and clearly problems such as race and race betterment from the viewpoint of this unit. Some of the best available are included below, together with a few books which present the classical eugenist's point of view—a point of view which involves certain interpretations and conclusions which many modern geneticists feel are not justified on the basis of the available data.

I. *For Students*

At the student level, there is especially little suitable reading. The high-school biology texts usually represent the classical eugenist's viewpoint and leave most of the other modern problems undiscussed. Some teachers, however, may find such treatments useful as a springboard into further discussion.

Of the books mentioned below, Furnas, Muller, and Huntington would make interesting reading for the able student who wishes to compare the two points of view on eugenics.

II. *For Teacher Use*

Cowdry, E. V., ed., *Human Biology and Racial Welfare* (New York, Paul B. Hoeber, Inc., 1930), xviii + 612 pp. A compilation of

articles on the wide range of topics indicated by the title. Among them the following may be useful for this unit:

Healy, "Antisocial Behavior, Delinquency, and Crime." Includes a short discussion of heredity and crime.

Lewis, "The Inheritance of Disease."

Dewey, "The Influence of Education."

Pearl, "Some Aspects of the Biology of Human Populations."

Davenport, "The Mingling of Races." Does not include discussion of the "Nordic problem."

Conklin, "The Purposive Improvement of the Human Race." Chiefly a survey of the available data, with some interpretations of the classical eugenist school.

FURNAS, C. C., *The Next Hundred Years: The Unfinished Business of Science* (Baltimore, Williams and Wilkins Co., 1936), xiv + 434 pp. The first chapter (pp. 7–22) is entitled "The Battle of Eugenics." Furnas has a quarrel with the more ardent eugenists. He expounds his own views in a direct and readable style.

*HOGBEN, Lancelot, *Nature and Nurture* (New York, W. W. Norton and Co., 1933), 9 + 143 pp. Although this rather small book is not easy reading, parts of it constitute one of the best sources of a modern point of view in genetics. Particularly useful is the first chapter (pp. 9–33) which gives a clear and penetrating discussion of the interdependence of heredity and environment and suggests some of the social implications of this. Among the other signally useful sections are pages 34–37 on the principle of random mating, and further discussion of nature and nurture, pages 91–98, 106–117 and 121 (especially pages 110, 117, 121).

HOLMES, S. J., *The Eugenic Predicament* (New York, Harcourt, Brace and Co., 1933), xi + 232 pp. Although its sympathies lie with the viewpoint of classical eugenics, this book presents a clear and reasonably dispassionate survey of the data as it appears to the orthodox eugenist. This unit, of course, has subscribed to a different viewpoint with regard to the interpretation of much of the data.

HUNTINGTON, Ellsworth, *Tomorrow's Children* (New York, John Wiley and Sons, 1935), x + 139 pp. Written in question and answer form. Easy reading, even for students. Represents, however, the viewpoint of classical eugenics with which this unit is not in entire agreement. Some good material.

HUXLEY, Julian S., and HADDON, A. C., *We Europeans* (New York, Harper and Bros., 1936), viii + 246 pp. This is a book which sheds much light on the confusions that surround the term *race* today. It discusses all the ways in which the word *race* is used. It analyzes each use of the word and reviews the pertinent data to decide what meanings *race* has when used in that sense. It considers the evidence for the existence of the Nordic race

as a separate entity, etc. The first parts of the book summarize material that is developed in greater detail as the reader proceeds. The style is clear and readable.

*Lange, J., *Crime and Destiny* (New York, Charles Boni Paper Books, 1930), 250 pp. Out of print, but obtainable in many libraries. This small readable paper-bound book is a comparative study (with case histories) of thirteen pairs of identical twins and seventeen pairs of fraternal twins, selected for study because in each case one twin had a criminal record. What about the other twin? Worth reading.

Muller, H. J., *Out of the Night* (New York, Vanguard Press, 1935), x + 127 pp. A clearly written book (readable by students). Muller is one of the important modern research geneticists. He turns his attention here to a popular and enjoyable discussion of man's emergence into a position where he can dominate the external world, but has still to accomplish the conquest of himself. Muller is optimistic, however, about this future conquest. The book begins by describing the elements of genetics, in the course of which the author makes use of some striking analogies. Man's present and future are then discussed and the important place that genetic knowledge will have in that future. Consideration is also given to the present problems of crime, race differences, eugenics, etc. Muller has a good deal to say about the fallacies of the classical eugenics arguments. He develops his own social philosophy. In conclusion he speculates entertainingly about the future.

Popenoe, Paul, and Johnson, R. H., *Applied Eugenics,* Rev. ed. (New York, The Macmillan Co., 1933), ix + 429 pp. A standard reference on classical eugenics.

Shull, A. F., *Heredity,* 2nd. ed. (New York, McGraw-Hill Book Co., 1931), xv + 345 pp. A college text in genetics covering the elements of genetics with some emphasis on the cellular basis of heredity and a good brief treatment of the measurement of variation. It is included in this classification, because it is especially concerned with "human affairs." Hence, there are chapters on human inheritance, genetics in agriculture, eugenics, population problems, race, immigration. These chapters, for the most part, stick to the known facts and make no sweeping conclusions. The most recent problems of race and recent viewpoints on eugenics (as discussed in this unit) are not reflected in the conclusions drawn. The book is a useful source for certain data—brief summaries of the U. S. legislation on immigration. The book is usable, in part, by older students.

*Thomson, J. Arthur, and Crowther, J. G., eds., *Science for a New World* (New York, Harper and Bros., 1934), xxii + 398 pp. The first article is "Heredity and Human Affairs," by Lancelot Hogben, one of the leading figures in modern genetics. Hogben

summarizes his views on the present implications of genetics for human living. He dismisses much of the classical eugenics program as relatively unimportant compared with the great need for better human environment. He stresses the importance of genetics research, however, and especially the contributions genetics can make to modern medicine.

D. Genetics and Agriculture

I. *For Students (and teacher)*

*De Kruif, Paul, *Hunger Fighters* (New York, Harcourt, Brace and Co., 1928), 377 pp. (cheaper edition in the Blue Ribbon Series). A vivid account of the life and work of the men who improved our wheat, corn, and meat. Popular style and very easy reading.

*East, Edward, ed., *Biology in Human Affairs* (New York, Whittlesey House, McGraw-Hill Book Co., 1931), xi + 399 pp. Contains chapter (pp. 318–363) by Donald Jones, "Efforts to Increase Food Resources." Interesting summary from earliest times to present.

Prentice, E. Parmalee, *Breeding Profitable Dairy Cattle* (Boston, Houghton Mifflin Co., 1935), xviii + 261 pp. An interesting and clearly written reference for any high-school student who is especially interested in cattle breeding. Good discussions of the genetics involved. Well illustrated.

**United States Department of Agriculture, *Yearbooks of Agriculture* (Washington, Government Printing Office, 1936, 1937). The United States *Yearbooks of Agriculture* for the years 1936 and 1937 are devoted solely (and that means a total of some 2,700 pages) to the genetics and breeding of farm plants and animals. These two volumes are a remarkable piece of work. Probably no more complete and up-to-date compendium of such information exists. Moreover, great pains have been taken to make them truly readable. One section of each volume contains summaries, each of them one or two pages long, of all the articles in the volume. These summaries make fascinating reading (for student or teacher) for they sketch in vivid and simple language the origin and early history of the plant or animal, recent developments in its breeding, and present prospects. The longer articles are straightforward discussions, well illustrated, and the compilations of specific data withheld until nearly the end so that many students will want to read at least part of an article as well as the summary. There are also excellent articles on the fundamentals of genetic theory. Each volume contains the detailed report of the Secretary of Agriculture, "The Year in Agriculture." The 1936 volume is devoted to major crop plants and animals, such as wheat, corn, sugar cane, cotton, flax, tobacco, cattle, swine, sheep, horses, poultry, etc. The 1937

volume continues with the various garden vegetables and fruits (including sub-tropical fruits and nuts), flowers, forage crops, soy beans, forest trees, goats, dogs, turkeys, fur-bearing animals, and honey bees. There are few better references for the student who wishes either general or detailed information about the agricultural side of genetics. These *Yearbooks* sell for $2.00 a volume. They may also frequently be obtained free through the local representative in Congress.

II. *For Teacher Reference*

Babcock, E. B., and Clausen, R. E., *Genetics in Relation to Agriculture* (New York, Mc-Graw-Hill Book Co., 1927), xiv + 673 pp. General treatment of genetic principles with special sections on crop plants and on animals.

Hunter, H., and Leake, H. Martin, *Recent Advances in Agricultural Plant Breeding* (Philadelphia, P. Blakiston's Son and Co., Inc., 1933), x + 361 pp. A British book which covers an extensive list of crop plants of the temperate, sub-tropical, and tropical zones, and includes some topics (for example, rubber, drugs, beverages) which are not discussed in the United States *Yearbooks of Agriculture.*

Loeb, Harold, and others, *The Chart of Plenty* (New York, The Viking Press, 1935), xv + 180 pp. A summary of the official report of the National Survey of Potential Product Capacity. Part of this report concerns the production of food supplies. Even in 1929 this country did not produce enough food (for example, milk, eggs) to feed its population adequately. Have we the resources to do so? How much is our knowledge of genetically superior plant and animal types put into practice? The data collected by the survey are clearly and readably set forth and summarized. The interpretations and conclusions presented are clearly separated from the data.

E. Special References for Laboratory Projects

Castle, W. E., *The Genetics of Domestic Rabbits* (Cambridge, Mass., Harvard University Press, 1930), vi + 31 pp. A small but authoritative volume. If only a little work with rabbits is to be done, however, considerable information on the genetics of rabbits is included in Snyder. (See "A" above.)

Keeler, Clyde E., *The Laboratory Mouse, Its Origin, Heredity, and Culture* (Cambridge, Mass., Harvard University Press, 1931), viii + 81 pp. Brief, but complete.

Kinsey, A. C., *Field and Laboratory Manual in Biology* (Philadelphia, J. B. Lippincott Co., 1927), xix + 151 pp. The laboratory manual which accompanies Kinsey's high-school biology

text, *New Introduction to Biology*. Includes simple experiments on the laws of chance and Mendelian ratios (pp. 71–85).

New York Association of Biology Teachers, *Adventures in Biology*, 1934, 2nd ed., to appear early in 1939. (To obtain write to Department of Biology, Grover Cleveland High School, Queens, New York City. Price 50¢.) A paper-bound booklet suggesting many interesting projects, together with references for student reading on each topic.

Turtox Science Leaflets. To obtain write General Biological Supply House, Chicago, Illinois. Entire series is free to teachers.

Of special interest for this unit are:

No. 15, "Culture of Drosophila Flies and Their Use in Demonstrating Mendel's Laws."

No. 26, "Making Biology Charts."

No. 27, "Lantern Slides Any Teacher Can Make."

(The Turtox Catalogue and Teacher's Manual, also free, contains considerable information useful to the biology teacher and some of the copious illustrations may suggest projects.)

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